[redacted]

15th February 2019

Reference 20014413

My name is Susan Kennedy and I am a Ramsgate resident. I'm a founding member of the No Night Flights group and a Ramsgate Town Councillor. I'm an educationalist and spent many years teaching in secondary schools. For the last 12 years I have been working in the NHS, specifically in medical education. My interest, particularly, in this submission is focused on the health and education aspects highlighted by the applicant's proposal.

I am opposed to the proposal on the grounds that the noise resulting from the plans would be seriously detrimental to the health, wellbeing, educational and life prospects of the children and adults within our town.

All references within this submission are supported by the documents to which they refer, provided as an appendix.

Aviation Noise

In July 2016 the European Commission published a summary of a report looking at how living with aircraft noise affects wellbeing. It found that:

Living within a daytime aircraft noise path (with noise at or above 55 decibels) … was negatively associated with all measures of subjective wellbeing: lower life satisfaction, lower sense of worthwhile, lower happiness, lower positive affect balance, and increased anxiety. The authors found consistently negative and significant results across all five variables. [1]

In a study produced by Queen Mary University of London for the Airports Commission, the conclusion was that:

> *The health effects of environmental noise are diverse, serious, and because of widespread exposure, very prevalent … For populations around airports, aircraft noise exposure can be chronic. Evidence is increasing to support preventive measures such as insulation, policy, guidelines, & limit values. Efforts to reduce exposure should primarily reduce annoyance, improve learning environments for children, and lower the prevalence of cardiovascular risk factors and cardiovascular disease.*[2]

"The World Health Organisation (WHO) have estimated sleep disturbance to be the **most adverse** non-auditory effect of environmental noise exposure (Basner et al., 2014; WHO, 2011). Undisturbed sleep of a sufficient number of hours is needed for alertness and performance during the day, for quality of life, and for health (Basner et al., 2014). Humans exposed to sound whilst asleep still have physiological reactions to the noise which do not adapt over time including changes in breathing, body movements, heart rate, as well as awakenings (Basner et al., 2014). The elderly, shift-workers,

[1] "How does living with aircraft noise affect wellbeing? A study of UK airports", Science for Environment Policy, Issue 462, 8 July 2016; based on: Lawton, R. and Fujiwara, D. (2016). Living with aircraft noise: Airport proximity, aviation noise and subjective wellbeing in England. Transportation Research Part D: Transport and Environment, 42: 104– 118. DOI: 10.1016/j.trd. 2015.11.002

[2] Queen Mary University of London, for the Airports Commission, Aircraft noise effects on health, May 2015, p27

children and those with poor health are thought to be at risk for sleep disturbance by noise (Muzet, 2007)."[3]

WHO is clear on aircraft noise. The Europe Night Noise Guidelines (WHO, 2009) advise that the target for noise at night should be 40dB $L_{night, outside,}$ on the basis that this is the level which should ensure protection of the public at large but, most specifically, vulnerable groups such as children, the elderly and those suffering from chronic health conditions. WHO suggests that moving incrementally towards such targets would see countries enforcing levels of 55dB $L_{night, outside}$.

There is ongoing study into people's perceptions of noise and the levels of noise at which quality of life (and health) is significantly adversely impacted. The Attitudes to Noise from Aviation Sources in England (ANASE) in 2007 concluded that:

> *"levels of annoyance reported by respondents increased with the sound level; people were concerned about noise at even low levels and particularly at night"*[4]

Subsequent studies have been critical of this 'old' data, however, and the focus on 'the onset of significant annoyance ' at 57 LAeq and the 'belief that communities below this noise exposure threshold are relatively unaffected by aircraft noise'.[5] It is increasingly clear that both health and wellbeing are significantly adversely impacted at 40-45dB.

Historic data and the lived experience of residents of Ramsgate show that we are talking about far, far higher levels of noise.

Examples below and full table attached

Location	direction	airline	date	runway	aircraft	registration	lmax	db
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	01/06/2003 10:16:00	28	DC86 9	GMKK	96.6	89.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	02/06/2003 11:44:00	28	B742 9	GMKP	99.6	93.5
Clarendon House Grammar School Monitor No.2	Departure	Iceland	02/06/2003 11:57:00	28	B742	TFARF	97	90.8
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	04/06/2003 13:30:00	28	B742 9	GMKQ	101	94.6
Clarendon House Grammar School Monitor No.2	Departure	Iceland	04/06/2003 13:44:00	28	B742	TFARF	98.2	92.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	06/06/2003 14:06:00	28	B742 9	GMKL	98.6	92.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	09/06/2003 10:37:00	28	B742 9	GMKL	97.3	90.8
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	10/06/2003 00:55:00	28	B742 9	GMKP	97.6	91.2
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	10/06/2003 11:36:00	28	B742 9	GMKQ	102	96.2
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	11/06/2003 07:24:00	28	DC86 9	GMKK	97.4	89.3
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	11/06/2003 10:43:00	28	B742 9	GMKL	98.5	92.3
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	13/06/2003 00:12:00	28	B742 9	GMKQ	101	96.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	19/06/2003 00:09:00	28	B742 9	GMKL	101	95.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	19/06/2003 10:35:00	28	DC86 9	GMKK	97.3	89.8
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	20/06/2003 11:54:00	28	B742 9	GMKP	98.5	92.4
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	27/06/2003 11:50:00	28	B742 9	GMKP	98.5	92.2
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	30/06/2003 00:44:00	28	B742 9	GMKL	98.2	92.2
St Nicholas Roundabout Monitor No. 1	Departure	BEC ???	01/12/2003 08:27:00	10	AN12	UN11373	87.7	77.3
St Nicholas Roundabout Monitor No. 1	Departure	BEC ???	01/12/2003 08:27:00	10	AN12	UN11373	87.7	77.3
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	01/12/2003 11:59:00	10	DC86	9GMKG	87.8	76.2
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	01/12/2003 11:59:00	10	DC86	9GMKG	87.8	76.2
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	02/12/2003 14:53:00	10	DC86	9GMKO	89.2	76.5
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	02/12/2003 14:53:00	10	DC86	9GMKO	89.2	76.5

[3] Queen Mary University of London, for the Airports Commission, Aircraft noise effects on health, May 2015, p5

[4] John Bates Services etc. for the DfT, ANASE: Attitudes to Noise from Aviation Sources in England, October 2007

[5] Ian Flindell & Associates and MVA Consultancy for 2M Group, Understanding UK Community Annoyance with Aircraft Noise: ANASE Update Study, September 2013,

Location	directi	airline	date	runwa	aircraft	registrati	lm	db
Unknown	Arrivals	MKA MK Airlines	05/01/2008 21:22:00	28	B742	GMKHA	99.4	91.8
Unknown	Arrivals	MKA MK Airlines	13/01/2008 14:41:00	28	B742	9GMKM	97.7	91.8
Unknown	Arrivals	MKA MK Airlines	18/01/2008 15:51:00	28	B742	TFARW	100	93.4
Unknown	Arrivals	MKA MK Airlines	27/01/2008 09:11:00	28	B742	GMKFA	98.3	91
Unknown	Arrivals	MKA MK Airlines	29/01/2008 15:49:00	28	B742	GMKGA	99.5	96.2
Unknown	Departure	MKA MK Airlines	29/01/2008 20:27:00	10	B742	GMKGA	103	96.3
Unknown	Arrivals	MKA MK Airlines	30/01/2008 13:13:00	28	B742	GMKHA	99.6	91.5
Unknown	Arrivals	MKA MK Airlines	05/02/2008 13:26:00	28	B742	GMKCA	99.1	91.5
Unknown	Arrivals	MKA MK Airlines	07/02/2008 14:07:00	28	B742	GMKGA	98.1	94.7
Unknown	Departure	AIN African International Airways	18/02/2008 22:19:00		DC85	ZSOSI	99.7	91.1
Unknown	Departure	AIN African International Airways	19/02/2008 18:39:00	10	DC86	ZSOSI	101	91.2
Unknown	Arrivals	MKA MK Airlines	21/02/2008 10:40:00	28	B742	GMKDA	99.1	92.4
Unknown	Departure	MKA MK Airlines	24/02/2008 00:47:00	10	B742	GMKBA	98.8	93.6
Unknown	Arrivals	MKA MK Airlines	24/02/2008 08:10:00	28	B742	GMKBA	99	92.4
Unknown	Arrivals	MKA MK Airlines	26/02/2008 17:47:00	28	B742	GMKHA	98.9	91.9
Unknown	Arrivals	CLX Cargolux Airlines	11/03/2008 14:28:00	28	B744	LXPCV	99	91.5
Unknown	Arrivals	MKA MK Airlines	14/03/2008 18:25:00	28	B742	N704CK	98.6	91.9
Unknown	Arrivals	MKA MK Airlines	18/03/2008 11:23:00	28	B742	GMKCA	98.1	92.2
Unknown	Departure	MKA MK Airlines	18/03/2008 15:48:00	28	B742	GMKCA	99.1	91.1
Unknown	Arrivals	MKA MK Airlines	21/03/2008 00:18:00		B742	GMKBA	106	106.5

Noise and health and wellbeing

The Planning Inspectorate and, even more importantly, residents actually have no way of knowing exactly what the potential noise impacts would be if RSP were successful in their application. This is because 'exact' operations that consider airspace options, flight paths, operating principles are not to be formalised through an Airspace Change Proposal (ACP) until after a DCO is granted. Similarly, in absence of an evidenced business plan with clear expressions of interest or solid indications about likely traffic and aircraft types, there is no way of knowing which aircraft would be flying over our heads. Even in terms of the numbers of ATMs per annum, RSP have played fast and loose with these figures over the years and through different consultations to their final application. With little way of knowing whether Ramsgate and beyond would be subjected to 17,000 or 83,000 ATMs, or anything in between, it is impossible do know what levels of noise could be expected. And yet RSP have presented a noise mitigation plan. Without supporting detail and evidence, this mitigation plan is scarcely worth the paper it is written on.

RSP's application suggests that the number of residents likely to be affected by their proposal (experiencing noise levels of 80dBs LAS) is around 20,000. The actual figure, based on historic data suggests much closer to 50,000 people. The sample noise monitoring tables provided above are from a larger set of monitoring data provided regularly at the Kent International Airport Consultative Committee and available in that committee's minutes. The noise monitors were positioned strategically at both east and west ends of the runway and were properly maintained. RSP should have provided the data recorded by these monitors and submitted to KIACC and I regard it as essential that they be required to do so as part of this examination stage of the process.

The Bickerdike Allen and Partners Report (2010)[6] and the Bureau Veritas Report (2010) which considered in detail noise impact, similarly, need to be submitted and interrogated by way of comparison to RSP's noise assessments and impact analyses. Both reports would suggest that RSP have failed to properly assess levels of noise, extent of noise impact and numbers of people impacted. A typical sleight of hand of RSP's is to present their 'numbers impacted' in terms of households rather than actual people. Given that it is actual people who will be adversely affected and that it is the numbers of people impacted needed in order to correctly and fully assess impact, this seems deliberate and unhelpful.

[6] Reading of Bickerdike Allen and Partners should be read with reference to more recent studies about the levels of noise at which noise significantly impacts, as cited previously (work by Ian Flindell and Associates). Similarly, the Bureau Veritas Report suggests that noise levels are understated by BAP.

What is clear is that RSP has deliberately underestimated and therefore downplayed the levels of noise and the impact of noise. They have chosen not to undertake serious analysis and use of the historic noise data that is available in order to assess impact.

Residents are naturally concerned that in presenting this application and noise plan to inspectors analysing the impact of a new airport, inspectors with little to no knowledge, one might presume, of the previous airport, RSP hopes to persuade in terms of their underestimations. Residents themselves know only too well the regular flight paths taken both day and night, the levels of noise, the impact of noise and this lived experience, this knowledge, is borne out by recorded levels of noise, and recorded complaints about noise, during the years when Manston operated. It should be noted that during the 15 years of its commercial life, Manston did not have night flights and those that were experienced were delayed flights. This points to their irregularity and lack of frequency and yet their impact was sufficient to warrant complaints and for residents to recall them with horror. Similarly, one should note the small scale of operations during the daytime. Most residents were insufficiently disturbed or alarmed by two or three flights a day. Given the noise of those daytime flights, an application proposing flights every 20-30 minutes, or even more is one that residents will resist given they can set this against previous lived experience and can anticipate the exponentially worse impact on their lives, health and wellbeing.

In their application, RSP state at 15.8.8 that there is a probability of 'one additional awakening', at most, 'each of three nights on average' and sets this against 'typical spontaneous awakenings at a rate of around 24 a night'. To place typical spontaneous awakenings against any awakening caused by excessive aircraft noise suggests such casual disregard for people as to be breath-taking. It also neglects to contextualise any awakenings through careful analysis of the significant and growing body of research on sleep, sleep disruption, noise impact events and, in particular, that relating to the impact of aircraft noise on populations, in general, and on specific demographic groups. Unfortunately, this disregard of a substantial evidence base is characteristic of the application, as a whole.

RSP's proposal must be properly interrogated in terms of its noise modelling and its noise mitigation plans for any robust consideration of the significantly adverse impact on people's health to be undertaken during this examination process. RSP should be obliged to furnish the inspectorate with proper comparative and historic data.

Impact of aviation noise

Children

Uninterrupted sleep over a minimum of 8 hours is vital for children's growth and, in particular, their cognitive development. Chronic and consistent aircraft noise exposure in children has been demonstrated to be associated with impairment of both reading and long-term memory.

The Munich Study[7] studied the effects of chronic noise and psychological stress on children living near Munich International Airport. This study was also able to investigate the impact on children living near the airport once the airport was relocated away from the study area and on those children who were newly living next to the relocated airport.

> *'Two of the cognitive tasks, recall and language mastery, showed the doubly replicated aircraft noise effect of disappearing when the old airport was closed down and coming forth when the new airport started to operate. This is a very strong empirical foundation for the conclusion*

[7] The Munich Airport Noise Study-Effects of Chronic Aircraft Noise on Children's Perception and Cognition, Hygge, S, Evans G W, Bullinger, M, InterNoise2000, 2000

that cognitive tasks requiring central language processing are particularly sensitive to noise.' [8]

In the Munich Study "*The authors concluded that in young children chronic noise exposure appeared to cause increased psychological stress, as measured by cardiovascular, neuroendocrine and affective indicators and that these effects occur even among children who suffer no detectable hearing damage while living in the immediate vicinity of an airport*."[9]

The RANCH project[10] examined relationships between aircraft noise exposure and school performance, annoyance and blood pressure in children aged nine to ten in the Netherlands, Spain and the UK. For the UK sample of the RANCH study, night noise contour information was linked to the children's home and related to sleep disturbance and cognitive performance.

"The RANCH results, considered with evidence from previous studies, suggests that aircraft noise has specific causal effectives on children's school performance and health. The functions adversely affected by noise are reading, recognition memory and annoyance. It is not known whether these effects are temporary or permanent.[11]

Results from both the Munich and RANCH studies suggest that night aircraft noise exposure does not appear to *add* (our italics) any cognitive performance decrement to the cognitive decrement already induced by a child's exposure to daytime aircraft noise. In other words, aircraft noise for developing children is **equally bad both day and night**.[12]

"Stansfeld et al (2010) also examined the effect of night-time aircraft noise exposure on the cognitive performance of children. This analysis was also an extension of the RANCH study, and the Munich study in which 330 children were assessed on their cognitive performance in three waves, each a year apart, before and after the switch over of airports. Aircraft noise exposure and self-reported sleep quality measures were analysed across airports to examine whether changes in night-time noise exposure had any impact on reported sleep quality, and if this was then reflected in the pattern of change in cognitive performance. In the Munich study, analysis of sleep quality questions showed no evidence of interactions between airport, noise and measurement wave, which suggests that poor sleep quality does not mediate the association between noise exposure and cognition. In the RANCH study, there was no evidence to suggest that night noise had any additional effect to daytime noise exposure. The authors explain that this investigation utilised secondary data and therefore was not specifically designed to investigate night time aircraft noise exposure on cognitive performance in children, but the results from both studies suggest that night time aircraft nose exposure does not appear to add any further deleterious effect to the cognitive performance decrement induced by daytime noise alone. They recommend that future research should be focussed around the school, for the protection of children against the effects of aircraft noise exposure on performance." [13]

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[8] The Munich Airport Noise Study-Effects of Chronic Aircraft Noise on Children's Perception and Cognition, Hygge, S, Evans G W, Bullinger, M, InterNoise2000, 2000, p3

[9] ERCD Report 0908 Aircraft Noise and Children's Learning, Civil Aviation Authority, 2010 – page 10

[10] Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health: Exposure-Effect Relationships and Combined Effects (RANCH Study), European Community funded, Queen Mary, University of London, Stockholm University, Sweden, Goteborg University, Sweden, National Institute of Public Health and the Environment, The Netherlands, Instituto de Acustica, Madrid, Spain, American Journal of Epidemiology, 2005

[11] RANCH Study – page 2

[12] Night-time aircraft noise exposure and children's cognitive performance, Stansfield S, Hygge S, Clark C, Alfred T, 2010 - Abstract

[13] ERCD Report 0908 Aircraft Noise and Children's Learning, Civil Aviation Authority, 2010 – page 32

More up-to-date even than the Munich and RANCH studies is NORAH, the Noise-related Annoyance, Cognition and Health noise impact study. This has been, to date, the most extensive study internationally on the effects of noise from aviation on the health and quality of life of the population.

> *"Aviation noise affects children not only in school. It has effects on their whole life and their wellbeing."* [14]
>
> *'In areas with high exposure to aviation noise, primary school children learn to read more slowly than children in quiet areas.'* [15]
>
> *'Teachers from areas with relatively high aviation noise exposure reported unanimously that the noise causes considerable disturbances to lessons. More than one third of the children from these schools are sometimes unable to hear the teacher properly due to aviation noise.'* [16]
>
> *'Ten percent of the parents in areas with relatively high noise exposure state that their children are currently taking prescribed medication. In the residential areas with medium exposure it was only four percent, and in the regions with low exposure just under six percent.'* [17]
>
> *'In areas with relatively high noise exposure, 14 percent answered "yes" to the question: "Has a doctor ever diagnosed a language or speech disorder in your child?" In areas with low noise exposure, only 10 percent gave this answer, in the residential areas with medium exposure it was 8 percent. These results are statistically unequivocal*.'[18]

The full NORAH Report is attached but the message is clear. Every year, more and more research is gathered which confirms the significantly negative impact of aviation noise on health. Thanet's children deserve more. Much more. Thanet falls into the most deprived decile in Kent where 66% of children do not achieve 5 good GCSEs compared to 23% in the most affluent decile. [19]

Summarising some of their conclusions, the authors wrote:

> *'This review has aimed to describe the main contributions in the field of aircraft noise and cognitive ability in children. The results are not completely in agreement, but there is evidence to suggest that chronic aircraft noise has a deleterious effect on memory, sustained attention, reading comprehension and reading ability. Early studies highlighted that aircraft noise was also implicated in children from noisy areas having a higher degree of helplessness i.e. were more likely to give up on difficult tasks than those children in quieter areas. This motivational decrement was reported in various studies, and it was suggested that this should be an area for future research over a longitudinal study protocol.'* [20]

With educationalists the world over focusing on 'grit' and 'resilience', the suggestion here that aviation noise impacts negatively on children's abilities to concentrate, to stick at activities, to give up, is a significant one. In an area like Thanet, where confounding factors such as health inequalities, poverty, single-parent households, relative lack of opportunity etc make life more difficult for local children that in other area of the county and country, there is an even more compelling case to ensure that additional adverse factors are not applied to the lives of our children.

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[14] NORAH, Knowledge No 1, Child Study: Effects of aviation noise on children, p6
[15] NORAH, Knowledge No 4, p2
[16] NORAH, Knowledge No 4, p2
[17] NORAH, Knowledge No 4, p10
[18] NORAH, Knowledge No 4, p12
[19] Mind the Cap:Health Inequalities Action Plan for Kent Analytical Report, Kent Public Health Observatory, 2016
[20] ERCD Report 0908, Aircraft Noise and Children's Learning, p18

The RANCH research team recommended that new schools should not be built close to existing airports. **It follows that new airports should not be built close to existing schools**. Schools in Ramsgate that are under the flight path are:

- Manston School House Nursery
- Chatham and Clarendon Grammar School
- The Elms Nursery School
- Priory County Infant School
- Fledglings Nursery School
- Ellington CP School
- Christchurch Church Primary School

As indicated from the screenshot below taken from RSP's documentation, *'significant adverse effects'* can be expected for these schools. The effects include disruption, disturbance or interference with tasks by the users of the building. The 'users' of these buildings are children and teachers. The 'tasks' that will be interfered with are learning activities.

*reduction from Year 2 due to phase out of Boeing 767 aircraft in the fleet

Permanent noise impacts at sensitive non-residential properties

12.9.57 **Table 12.26** presents predicted daytime noise levels resulting from the Proposed Development's probable route in Year 20 at sensitive non-residential receptors which are potentially impacted by aircraft noise.

12.9.58 Considering the magnitude of the impacts and the sensitivity of the receptors, significant adverse effects have been identified at the following non-residential receptors:

- Manston School House Nursery
- Chatham & Clarendon Grammar School
- The Elms Nursery School
- Priory County Infant School
- Masque Theatre School
- Fledglings Nursery School
- Ellington Cp School
- Christchurch Church
- Spitfire & Hurricane Memorial Building
- Pie Factory Music

12.9.59 The significant effect will be characterised by potential disruption, disturbance or interference with tasks by the users of the buildings.

12.9.60 The magnitude of the effect will depend on the existing ambient noise level at these receptors. For example at receptors which are already exposed to transport noise levels in excess of the impact

Both night time and daytime exposure to aviation noise impacts negatively on children's health, wellbeing and ability to learn. Stansfield et al particularly emphasise the need for '*school to be the main focus of attention for protection of children against the effects of aircraft noise on school performance'*.[21] RSP's woeful noise mitigation plan does not offer any reassurance here. Ramsgate schools, as with all schools, are suffering the impact of stringent cuts and are ill-placed to be able to

[21] Night time aircraft noise exposure and children's cognitive performance, Stansfeld, S, Hygge, S, Clark C, Alfred, T, Noise Health, 2010

put in place sufficiently effective noise insulation. In some case, old school buildings in conservation areas would be unable to ensure the most effective noise insulation because of planning restrictions.

Of course, no amount of insultation protects children from noise when outside playing or involved in sporting or other outdoor educational activities. Schools near Heathrow have resorted to building outdoor 'pods' for children to play in to protect them from the noise overhead. This is not a solution that seriously enhances children's performance and wellbeing. A simpler solution is not to build a noisy 24/7 cargo hub so close to so many schools in an area of already relative deprivation.

In addition to the impact on cognitive function and development, studies have posited the detrimental effect on the physical health of children exposed to aviation noise nuisance in the short and long-term.

> *"An imbalance between leptin and ghrelin can lead to an increased sense of hunger with weight gain as a consequence. The risk of diabetes due to sleep disturbance and poor cognitive performance have been identified as accompanying long-term effects of disturbed circadian rhythms."*[22]

Levels of obesity in some of the most deprived wards in Ramsgate, e.g. Newington, are already disproportionately high. These children and their families do not need an aggravating factor of this magnitude.

RSP says in its Environmental Statement at 15.8.10

> *"Depending on the existing ambient noise environment and existing building fabric, disruption to learning with measurable effects on reading age for children is possible at affected schools,*

[22] The Effects of Noise Disturbed Sleep in Children on Cognitive Development and Long-Term Health, published in the Journal of Child and Adolescent Behaviour in 2015 – page 6

prior to further mitigation. ***This could adversely affect quality of life and prospects for children concerned****."* [Emphasis added]

RSP acknowledges the serious adverse effect on quality of life and prospects. Yet their approach has been to ignore these children. Their application has not made any serious attempt to contextualise noise impacts in relation to these specific children, this specific population, these specific communities.

The Health and Social Care Act 2012 places a statutory duty on health services to reduce inequalities in health. There are severe inequalities with regard to the health of children in the UK and within Kent, and children in Thanet suffer some of the poorest health and health outcomes in the country.[23]

> *"Thanet is within the worst quintile in the UK for inpatient costs for under 5-year olds for a number of conditions including neurological, cancer and gastro-intestinal specialties but Thanet performs particularly poorly for musculoskeletal specialties with the second highest costs nationally per 1,000 population."*[24]

Thanet also has a higher percentage than average of looked-after children. It is unacceptable that children living in an area which places them at serious health disadvantage - children living in an area where their life chances are already compromised - should be subjected an additional 'significant adverse effect' by RSP's aviation proposal and to the seriously detrimental impact of aviation noise on them as clearly identified by academic and medical research.

[23] Kent Annual Public Health Report, 2015

[24] Thanet Clinical Commissioning Group, Annual Report 2015/16 – page 12

Adults, the elderly, those living with chronic illness, those with mental health issues

The elderly are also at specific and particular risk of adverse health impacts as are those with pre-existing health conditions. Thanet has higher proportion of elderly people than the national average. An ageing population puts an increased burden on health services including mental health services – all of which are increasingly hard-pressed and over-stretched. A disproportionately high elderly population means higher levels of complex health and care needs and the higher prevalence of physical health conditions in this older age group contributes to higher rates of depression.

Thanet also has a high proportion of people with mental health needs. There is a high prevalence in the area of a wide range of unhealthy behaviours, such as smoking, binge drinking, obesity and generally unhealthy eating, all of which contribute to the disproportionately unhealthy population and the significant health inequalities of the area. Thanet has the highest rates of substance misuse in Kent, with drug and drink abuse resulting in significant health issues and needs. The life expectancy of Thanet residents is the lowest in Kent with very significant variations within Thanet itself. Thanet has a high mortality rate from coronary heart disease and there are significantly poorer outcomes for people with Chronic Obstructive Pulmonary Disease (COPD) in the area. Thanet has the highest prevalence of people with mental health issues compared to similar areas nationally. There is the 4th highest rate in England of emergency admissions for people aged 75 plus (with a stay of under 24 hours). Thanet has one of the highest rates of undiagnosed dementia in England.[25]

Thanet has a disproportionately aged population, a trend that is set to increase. In conjunction with the relatively high prevalence in the area of dementia and other chronic conditions, many associated with older age, the high number of care homes, in addition to the frail elderly being cared for at home, has been given scant attention by RSP. A thorough review of the numbers of care homes under the flight path and within the general area should have been undertaken and specific consideration given to the vulnerabilities of the people who live within these homes. Cross-cutting factors need to be considered across all demographic groups but perhaps in particular with regard to the cared-for elderly. Depression, for example, in older people affects up to 25% of the population and up to 40% of those living in care homes.[26] Noise insulation plans, in general, would not address the specific needs of this particularly vulnerable section of the population. In addition, the proposal's impact on their inability to enjoy and benefit from being outside should have been considered.

Thanet is an area of significant deprivation. The health impacts of aviation noise are well and increasingly evidenced. A proposal which acknowledges, yet significantly underestimates, the impact of noise on a population already hugely disadvantaged cannot be supported. The detrimental effects on the whole population but, most significantly, on the most vulnerable and at risk, cannot be ignored.

In recent years, the evidence that aviation noise impacts negatively on cardiovascular health has mounted. Increased risk of hypertension, heart attack and stroke are significant. Babisch and van Kamp (2009) evaluated the exposure-response relationship of the association between aircraft noise and the risk of hypertension. Due to the absence of large-scale quantitative studies there has been no clear association found between aircraft noise, ischemic heart disease, and myocardial infarction. However:

> *"There is sufficient qualitative evidence, however, that aircraft noise increases the risk of hypertension in adults."*[27]

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[25] Thanet Clinical Commissioning Group, Annual Report, 2015/16

[26] Age Concern. Improving services and support for older people with mental health problems. London: Age Concern; 2007 (cited in Mental Health Needs Assessment for Adults in Kent, Thanet CCG, 201)

[27] Environmental Research and Consultancy Department (ERCD), Civil Aviation Authority) Report 1208, Aircraft Noise, Sleep Disturbance and Health Effects: A Review, 2013 – page 37

The health effects of environmental noise created by aviation operations are diverse, serious and because of widespread exposure, very prevalent. For populations around airports, aircraft noise exposure can be chronic. The WHO guidelines for exposure to environmental noise are clear and the proposals from RSP would represent a breach of these guidelines.[28]

A study investigating the association of aircraft noise with risk of stroke, coronary heart disease and cardiovascular disease in the general population in 12 London boroughs and nine districts west of London found distinct and statistically significant trends.

> *'Hospital admissions showed statistically significant linear trends (P<0.001 to P<0.05) of increasing risk with higher levels of both daytime (average A weighted equivalent noise 7 am to 11 pm, $L_{Aeq,16h}$) and night time (11 pm to 7 am, L_{night}) aircraft noise. When areas experiencing the highest levels of daytime aircraft noise were compared with those experiencing the lowest levels (>63 dB v ≤51 dB), the relative risk of hospital admissions for stroke was 1.24 (95% confidence interval 1.08 to 1.43), for coronary heart disease was 1.21 (1.12 to 1.31), and for cardiovascular disease was 1.14 (1.08 to 1.20) adjusted for age, sex, ethnicity, deprivation, and a smoking proxy (lung cancer mortality) using a Poisson regression model including a random effect term to account for residual heterogeneity. Corresponding relative risks for mortality were of similar magnitude, although with wider confidence limits. Admissions for coronary heart disease and cardiovascular disease were particularly affected by adjustment for South Asian ethnicity, which needs to be considered in interpretation. All results were robust to adjustment for particulate matter (PM_{10}) air pollution, and road traffic noise, possible for London boroughs (population about 2.6 million). We could not distinguish between the effects of daytime or night time noise as these measures were highly correlated.'*[29]

Much of the research to date does not distinguish between daytime and night-time aircraft noise or have not been able to distinguish the separate causal links of daytime and night-time noise for a population that is exposed to both, or have not been carried out in people's own homes, or have insufficiently considered confounding factors. It is clear, however, that aircraft noise – day and night - has a detrimental impact on human health and wellbeing.

The Civil Aviation Authority's ERCD Report 1278, Aircraft Noise and Health Effects examined research evidence published since 2009 relating to transportation noise, in particular aircraft noise and the resulting impacts on various health endpoints. The findings within this paper should be carefully considered:

> *"It was reported that the results obtained when using the same categories for daytime and night time aircraft noise indicated that the relative risks for mortality were higher for night time noise."*[30]

> *"There is a need to understand the burden of disease and disability-adjusted life years in relation to noise exposure and cognitive impairment. To this end, longitudinal studies are needed for understanding the causal pathways between noise exposure and cognition. The long-term consequences of aircraft noise exposure, during early school life, on later cognitive development and educational outcomes have not yet been studied and remain important for policy making decisions. It is recommended that greater understanding is needed of the mechanisms of working memory and episodic long-term memory in children in relation to noise effects."*[31]

The research into causal links between aircraft noise, day, night-time and 24 hour, continues to mature and it is essential to consider the weight of evidence and interpretation over time and of most

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[28] Aircraft Noise Effects on Health, Queen Mary, University of London, 2015, for the Airports Commission – pages 26 to 27

[29] Aircraft Noise and Cardiovascular Disease Near Heathrow Airport in London, Hansell, A et al, BMJ, 2013

[30] ERCD Report, 1278, Aircraft noise and health effects: recent findings, 2016 – page 17

[31] Ibid – page 64

recent years. What is clearly established is that there is significant adverse effect on human health, in particular for those people in the most vulnerable groups.

The RSP proposal insufficiently examines risk, research and the real evidence available of the levels of noise that resulted from previous operations at the past airport. The result of these omissions is that RSP considerably downplays the negative impact on the local population of the day and night ATMs that it plans.

There are still relatively few studies that specifically look at the impact of aircraft noise on mental health. Some studies have provided support for the idea that 'psychological stress is induced by aircraft noise exposure, resulting in hypothalmus-pituitary-adrenal axis dysregulation and a flattened cortisol rhythm and, notably, a lower ability to decrease cortisol levels at night.'[32] The field is still immature and much work needs to be done, however, most studies confirm that there is a significant relationship between noise sensitivity or annoyance due to aircraft noise and psychological ill-health. 'This supports the hypothesis that psychological aspects, such as noise annoyance and noise sensitivity play important roles in the association between environmental noise and adverse effects on health.'[33] Given that Thanet has the highest prevalence of people with mental health issues compared to similar areas nationally. At Dashwood Surgery, under the flight path, the data show that there is a high recorded prevalence of depression and poor mental health, with values in the upper quartile for GP practices in Kent.[34]

It is unacceptable that RSP has failed to consider people with mental health issues as a significantly vulnerable group within the area and, accordingly, looked at their proposal with this group in mind. The fact that they have not done so is consistent with their blasé approach that the noise will be relatively minor and only small numbers of the population will be adversely impacted. This cavalier attitude towards a proper segmentation and consideration of particularly vulnerable sections of the population is evident throughout their application.

Noise at Night

Even though this is a developing field, and even though there is a need for further research fully to separate out the adverse impact of night noise and day noise, there have been many studies looking in particular at the impact of aircraft noise at night time on adults. Due to the increasing body of evidence showing that there is a negative impact on populations exposed to aviation noise nuisance at night, an increasing number of international and national policy guidelines and directives are seeking to prevent or decrease the numbers of night flights at airports where a large population would be adversely affected.

The HYENA study examined the impact of aviation noise on blood pressure in adults living near seven major European airports including London Heathrow.

> *"The HYENA study found that a 10dB increase in aircraft noise at night was associated with a 14% increase in odds for high blood pressure."*

[32] Lefèvre, M.; Carlier, M.-C.; Champelovier, P.; Lambert, J.; Laumon, B.; Evrard, A.-S. Effects of aircraft noise exposure on saliva cortisol near airports in France. Occup. Environ. Med. 2017, 612–618. (cited in Aircraft Noise and Psychological Ill-health: The Results of a Cross-Sectional Study in France, International Journal of Environmental Research and Public Health, 2018)

[33] Aircraft Noise and Psychological Ill-health: The Results of a Cross-Sectional Study in France, International Journal of Environmental Research and Public Health, 2018, page 1)

[34] Thanet CCG, Analysis of Deprived Areas, 2016, p 14

"It also found that a 10dB increase in night time aircraft noise was associated with a 34% increase in the use of medication for high blood pressure in the UK."[35]

A research study carried out in Greece with people living near to Athens International Airport, as published online in Occupational and Environmental Medicine, found significant adverse effects.

'Between 2004-6 and 2013, 71 people were newly diagnosed with high blood pressure and 44 were diagnosed with heart flutter (cardiac arrhythmia). A further 18 had a heart attack.

Exposure to aircraft noise, particularly at night, was associated with all cases of high blood pressure, and with new cases.

When all cases of high blood pressure were included, every additional 10 dB of night-time aircraft noise was associated with a 69% heightened risk of the condition. When only new cases were included, every additional 10 dB was associated with a more than doubling in risk.'[36]

Elmenhorst et al (2010) looked at night time aircraft noise and the impact on cognitive performance the following day:

"The authors propose that the results hint at changes in physiological processes due to nocturnal aircraft noise exposure. Only healthy adults were included, however, the researchers infer that the effects of nocturnal aircraft noise may result in stronger impairment in vulnerable groups such as children or people who are ill."[37]

The significance of sleep to human health is increasingly being investigated as it is during the night that the body undergoes specific restorative functions. Anything that prevents this necessary physiological 'repair' work and energy saving functions can be detrimental to health:

"Often, there is a discussion that sleep represents a trophotopic phase (energy storing), contrasting with an ergotropic (energy consuming) phase when we are awake (Maschke and Hecht 2004). Therefore, frequent, or long-awakening reactions endanger recovery and therefore health. Such frequent occurrences of arousal triggered by nocturnal noise can lead to a deformation of the circadian rhythm. Also, the deep SWS phases in the first part of the night are associated with a nadir of cortisol, and a maximum of growth hormone, both necessary for the physical wellbeing of the sleeper."[38]

Research showing an association with aircraft and road noise and cardiovascular disease measures continues to mature. There is emerging evidence to suggest that cardiovascular effects are more strongly linked with night time noise exposure as opposed to day or total (24hr) noise exposure.

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[35] Aircraft Noise Effects on Health, Queen Mary, University of London, 2015, for the Airports Commission – page 3

[36] BMJ. "Long term exposure to aircraft noise linked to high blood pressure: Night-time noise may be particularly influential, findings suggest." ScienceDaily. ScienceDaily, 13 June 2017. <www.sciencedaily.com/releases/2017/06/170613185148.htm>.

[37] ERCD Report, 1278, Aircraft noise and health effects: recent findings,2016 – page 50-51

[38] ERCD Report 1208, Aircraft Noise, Sleep Disturbance and Health Effects: A Review,2013 – page 39

“With regard to night noise and sleep disturbance, there is growing recognition that average indicators such as Lnight are insufficient to fully predict sleep disturbance and sleep quality and that use of number of noise events (LAmax) will serve to help understanding of noise-induced sleep disturbance.” [39]

The NORAH Sleep Study examined how nocturnal flights affect people’s sleeping habits. The study paid special attention to the effects of two new measures, which changed the noise background in the Rhine-Main Region in October 2011. Since then there has been a curfew at Frankfurt Airport on scheduled take-offs and landings between 11 pm and 5 am. At the same time, the new North-West runway began operations. A comparison of the sleep measurements from 2011 and 2012 shows how the changes affected residents with otherwise healthy sleep patterns.

‘The residents around Cologne/Bonn Airport got less rest when they were asleep than the Frankfurt study participants after the introduction of the curfew on scheduled flights between 11 pm and 5 am. According to the sleep measurements carried out in the Rhineland, the participants spent less time per night in the deep sleep phase which is so important for rest.’[40] *12*

‘With the new “vegetative-motor” method used by NORAH, the focus of the scientists was brought back to the fact that nocturnal overflights can, in many cases, increase the heartbeat of sleepers. It even happens that people appear to continue sleeping peacefully, but still show a physical reaction.’[41]

The NORAH study on health risks produced a number of findings:

‘For aircraft noise, the NORAH team found a statistically significantly increased stroke risk in persons with a long-term energy equivalent sound level below 40 dB if the maximum sound level at night exceeded 50 dB.’[42]

In terms of cardiac insufficiency, where the heart is no longer able to sufficiently supply the body with blood, the NORAH study showed a statistically significant increase of 1.6% per 10dB.[43]

It is evident that there are particular and specific negative health impacts associated with aircraft noise at night time and it is important that the inspectors read the body of evidence available to date that confirms this.

Consulting with regard to health and wellbeing

RSP has undertaken only the bare minimum of consultation with regard to the population’s health and wellbeing. There has been consultation with the Kent Director of Public Health and the Clinical Chair of Thanet Clinical Commissioning Group but two individuals is extremely limited and falls significantly short of the sort of consultation, research and referencing that would be considered best practice.

In preparing their noise impact assessment, a full range of stakeholders should have been consulted. With regard to the specific population potentially impacted by this proposal, a wide range of clinical opinion, particularly with regard to existing chronic health conditions prevalent in the local population and those particularly likely to be aggravated by the adverse impact of aircraft noise, should have been consulted. A full range of mental health experts; teachers, headteachers and educationalists;

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[39] ERCD Report, 1278, Aircraft noise and health effects: recent findings,2016 – page 65

[40] NORAH< Knowledge No 10, Aviation noise and nocturnal sleep, p 12
[41] NORAH< Knowledge No 10, Aviation noise and nocturnal sleep, p 16
[42] NORAH, Knowledge No 12, Study on Health Risks, p 8
[43] NORAH, Knowledge No 12, Study on Health Risks, p 9

allied healthcare professionals; social care specialists and practitioners and care home owners and managers should have been interviewed.

Underpinning their application, with regard to noise impact, specifically in relation to health and wellbeing, should have been a solid body of evidence drawn from the widest range of up-to-date research on this topic in addition to a close and contextualised analysis of the specific health, wellbeing and health inequalities position locally. Only by doing this could RSP establish a credible health and wellbeing baseline.

It is vital that RSP consider fully the impact of its proposals on populations already deprived, already suffering some of the worst health inequalities in the country, already marginalised and under-supported by health and care provision. They have failed to undertake a credible impact assessment.

RSP's summary of community health needs and objectives (15.4.3 onwards) appears to suggest that correcting lifestyle and behaviour choices in the population, as part of local authority and health services planning and objectives, will result in improved health in the local population and therefore RSP needs to pay less attention to the adverse health impact of its proposal. This optimistic approach fails to consider the wider adverse impacts of RSP's proposal on environment, lifestyles, local regeneration and local communities etc. that may in themselves mitigate against any hoped-for improvements in lifestyle choices planned for against the status quo. RSP says that the Thanet CCG Chair noted 'the need for jobs in Thanet with the importance of socio-economic benefits to health'. However, this is not the same as the Thanet CCG Chair saying that RSP's proposal will have a net positive impact on health locally. One could equally say that the jobs proposed by the landowner of the airfield site would bring about the same desired health benefits.

In Table 15.4, RSP acknowledges that impact characteristics during the operational phase of its proposal with regard to airport and aircraft noise are "direct, adverse, local and long-term". Similarly, with regard to airport/aircraft air pollutant emissions, the impact characteristics are "direct, adverse, local and long-term". At 15.8.4, the applicant says that:

> "*These results indicate that the Proposed Development would lead to a potential 2% to 3.6% increase in cases of hypertension within the population exposed to Year 2 noise levels, rising to approximately 3.2% to 5.6% additional cases at Year 20 levels"*
>
> *"The evidence suggests that the relative change in noise also has the potential to contribute towards approximately one annual incident case of disease or mortality from ischaemic heart disease or stroke at Year 2 levels, rising to around two to four cases at Year 20 levels. This corresponds to a 2.8% to 4.3% change in background incidence*."

The applicant has not demonstrated how any benefits that could conceivably flow from its proposals would outweigh the cost in additional disease and death for the local population.

As has already been discussed in the foregoing sections on noise and night flights, the basis on which RSP's health impact predictions are made is fundamentally flawed and the adverse impacts described can be expected to impact a far higher proportion of the population. RSP must be interrogated on its noise contouring and noise methodology. RSP should be required to consider a more realistic assessment of the adverse impact of its proposal on health taking onto account the historic noise data relating to the airport and the WHO's evidence about the impact of noise on health.

Independent Commission on Civil Aviation Noise

As a result of one of the Airports Commission's recommendations, the Independent Commission on Civil Aviation Noise (ICAAN) is being set up. This publicly funded body is established with the 'statutory right to be consulted on flight paths and other operating procedures.' The authority is to be given 'statutory consultee status and a formal role in monitoring and quality assuring all processes and functions which have an impact on aircraft noise and in advising central and local Government and the CAA on such issues.'[44] (page 14)

The DfT's success criteria for ICCAN include that 'the SofS is effectively supported in his role with regards to noise within strategically significant decisions'. With regard to this specific application, it appears that the ICCAN may be insufficiently mature to be able to present evidence into the process and for it to advise the SofS. Notwithstanding, it would not be within the spirit of the Airports Commission recommendations nor the subsequent setting up of ICCAN for this examination process to ignore this body. Given its statutory role, given that this is the first DCO with regard to an airport, given government policy that has rejected the creation of new airports, given that government policy in no way supports the development of a 'nationally significant' cargo airport at Manston, given government and international principles and guidelines with regard to noise, it seems inconceivable that the this process and the SoS decision-making should be undertaken in absence of any input form this body.

Conclusion

RSP's proposal represents a serious threat to the people of Ramsgate.

It's noise modelling and noise mitigation plans are fundamentally flawed and completely underestimate noise levels and noise impact on many more thousands of people than they allow for.

With such serious flaws in their methodology and presentation, it is impossible for their noise impact assessment to be credible. If proper consideration of the adverse impact of aviation noise on local populations and their health is to be undertaken, their proposal must be fully interrogated and rewritten.

Essential to this examination stage is a full presentation and questioning of comparative and historic noise data which sheds an entirely different light on the applicant's proposal. Deliberately underplaying the extent to which noise will impact on people has consistently been a tactic that seeks to present only alleged benefits. RSP's proposal is simply not in any alignment with international and national guidance and directives, let alone principles, with regard to aviation noise and population health and wellbeing.

The National Planning Policy Framework (NPPF) says that 'the planning system can play an important role in facilitating social interaction and creating healthy, inclusive communities (Paragraph 68). It is to be hoped that the planning system recognises this role and refuses this application.

[44] House of Commons Briefing Paper, Number SN261, 2017

KENT PUBLIC HEALTH OBSERVATORY

Mind The Gap: Health Inequalities Action Plan for Kent

Analytical Report

June 2016

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Contents

1. Executive summary

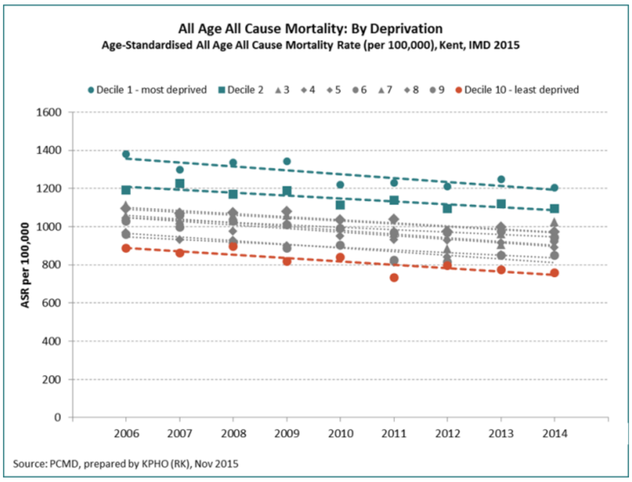
1.1 Introduction

This analysis was conducted to help inform the 2015 Public Health Annual Report and the forthcoming Mind the Gap: Health Inequalities Action Plan for Kent 2016. The analysis seeks to provide greater understanding of the true nature of the health inequalities in Kent.

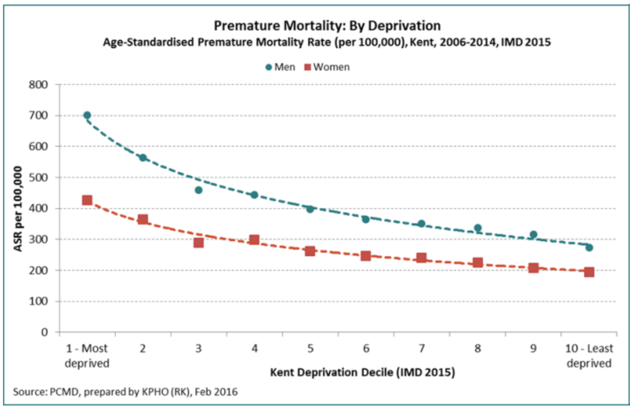
1.2 Key findings

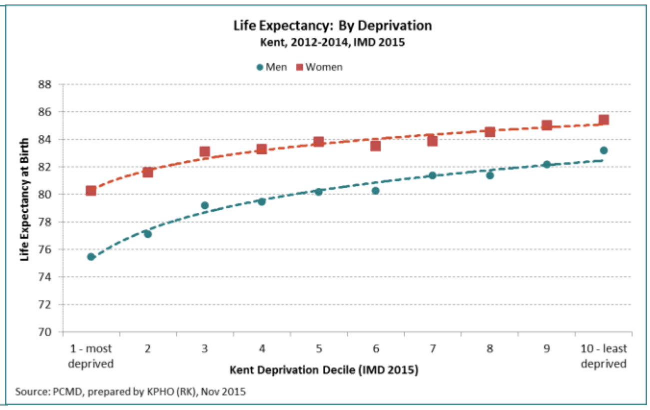
1.2.1 Inequalities in health outcomes

Whilst mortality rates in Kent have been falling over the last decade, the 'gap' in mortality rates between the most deprived and least deprived persists. This gap is particularly large for the most deprived deciles.



The most deprived populations have disproportionately worse premature mortality rates and life expectancy. This is demonstrated by the non-linear nature of the relationship between these high level health outcomes and deprivation.





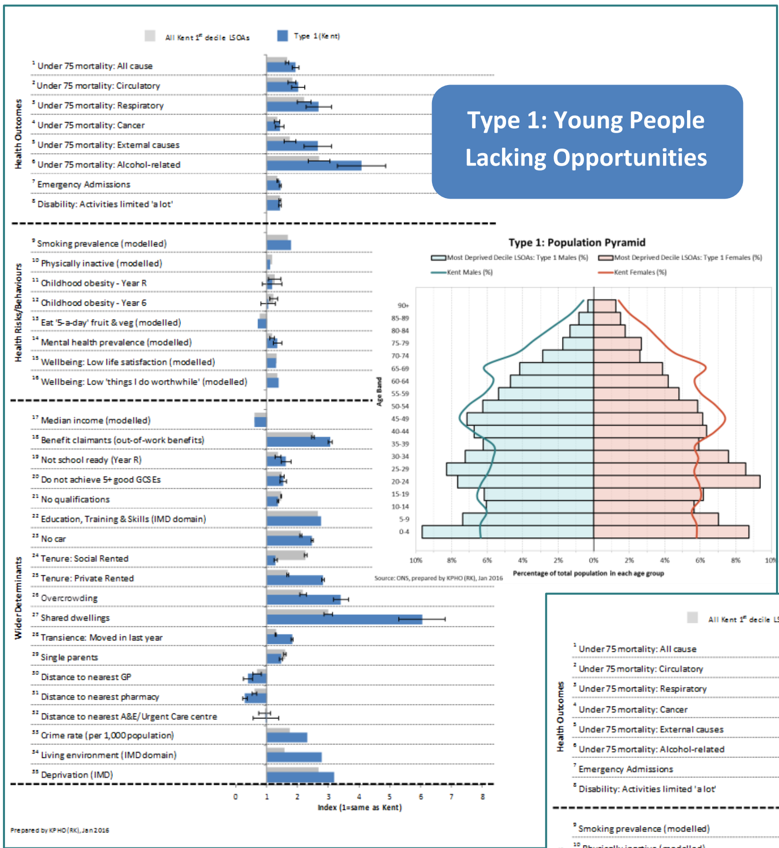
There are also inequalities in the causes of premature mortality. In the more deprived deciles, an increased proportion of the deaths are caused by cardiovascular, respiratory and GI disease.

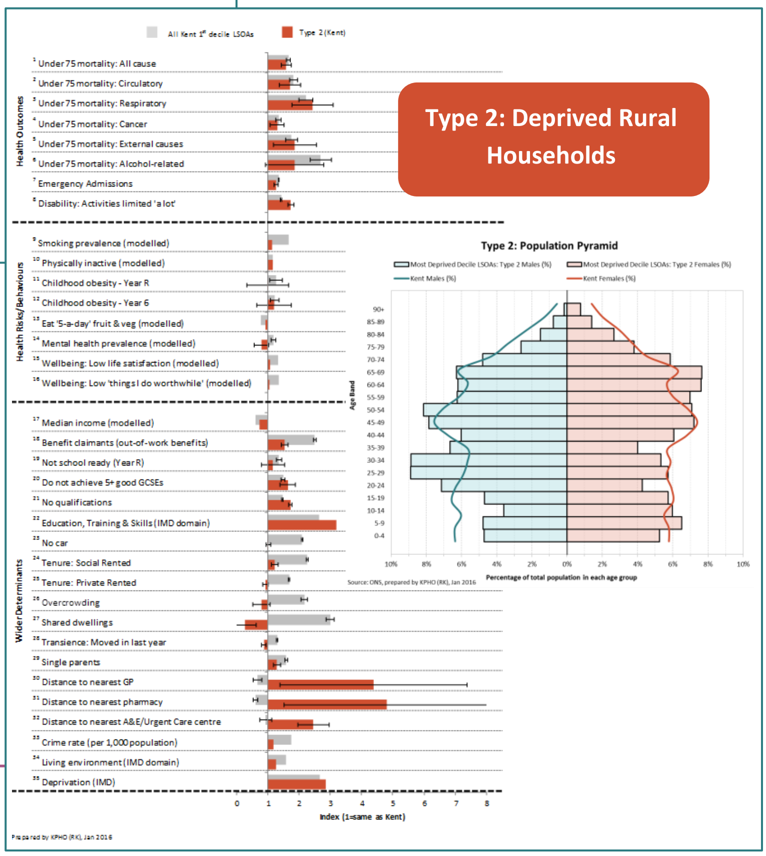
1.2.2 Inequalities in the wider determinants of health

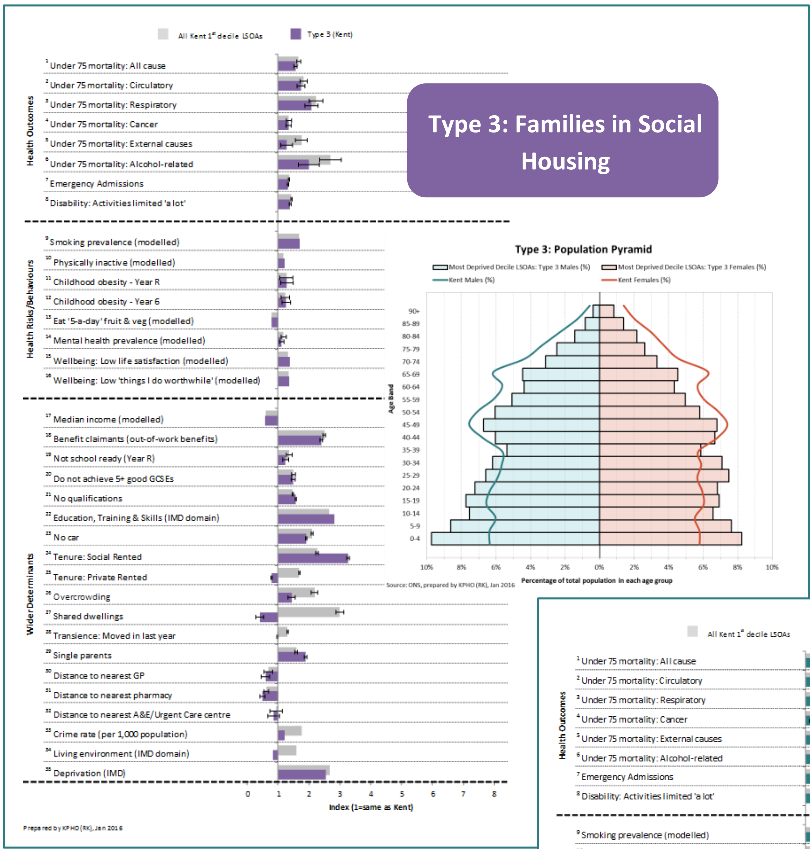
Steep inequality gradients are also evident across a large number of health and social indicators in Kent. On many measures the most deprived deciles fare disproportionately worse than their more affluent counterparts (i.e. there is a non-linear relationship with deprivation). For example, alcohol-related premature mortality is six times higher in the most deprived decile than the most affluent decile.

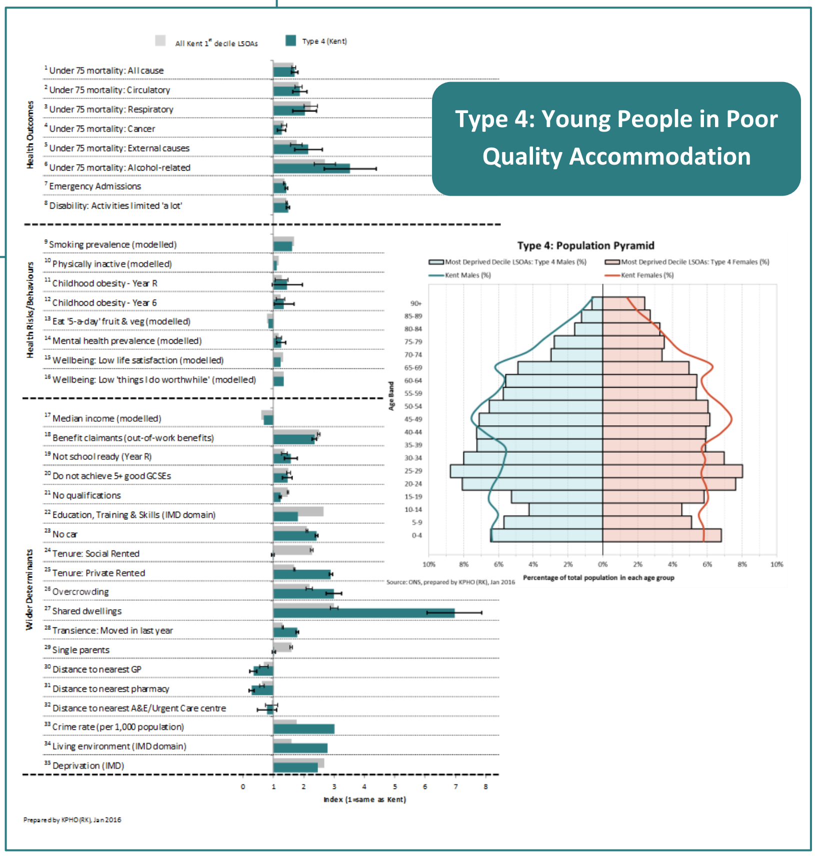
1.2.3 Types of deprivation

The LSOAs identified as falling into the most deprived decile in Kent have been subdivided using multivariate segmentation techniques. This segmentation sought to divide the most deprived LSOAs into 'types', so that within a 'type' areas are similar and between 'types' they differ. The analysis produced four distinct types.









1.3 Call to action

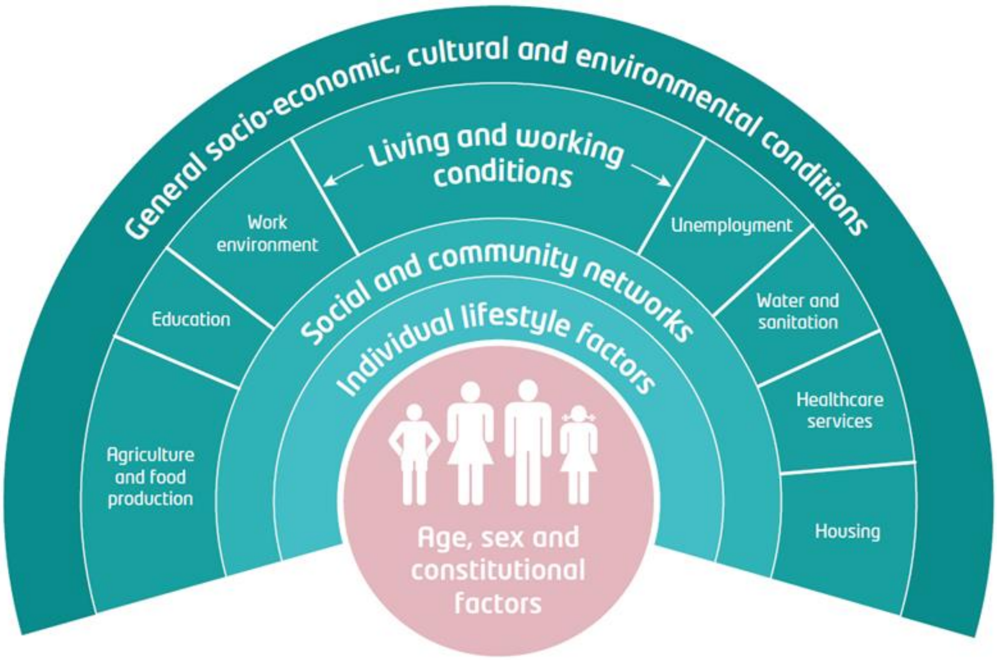
The forthcoming Mind the Gap: Health Inequalities Action Plan for Kent 2016 will include recommendations for action on health inequalities.

2. Introduction & objectives

Health inequalities are the differences in health outcomes within and between communities. We measure health inequalities overall through health statistics such as life expectancy or all-age, all-cause mortality rates or more specifically for specific disease mortality rates such as cancers, cardiovascular or respiratory disease rates.

It is now widely recognised that our health as individuals is shaped by the conditions in which we are born, grow, live, work and age[1].

Thus policy makers for health have to consider the wider set of economic, political, and social forces and systems which influence our daily lives. These wider determinants of health drive the health inequalities which exist in society; that is, the unfair and avoidable differences in health status between individuals depending on their life circumstances.



Dahlgren and Whitehead's Social Model of Health (1991)

Whilst Kent as a whole scores above the England average on a range of health indicators, this hides the great diversity and disparities which exist within, and between, Kent's communities.

[1] UCL Institute of Health Equity. Fair Society, Healthy Lives: The Marmot Review - Strategic Review of Health Inequalities in England post-2010. 2010.

In 2012 the 'Mind the Gap' action plan was formulated by Kent County Council to reduce the gap in health status between the least deprived and most deprived communities in Kent[2]. The 2015 Public Health Annual Report[3] is dedicated to health inequalities and reinforces the need to remain focussed on reducing the 'gap' in health outcomes across the county.

As part of the work surrounding the production of the 2015 Public Health Annual Report, the Kent Public Health Observatory (KPHO) were asked to provide intelligence and analytic support to bring greater understanding of the true nature of the health inequalities we see in Kent. This work has also been used to inform the forthcoming Mind The Gap: Health Inequalities Action Plan for Kent 2016[4].

The specific objectives of our analysis were as follows:

- To explore trends in inequalities in health outcomes in Kent
- To explore inequalities in both health outcomes and the wider determinants of health
- To provide further understanding of the most deprived areas in Kent, using segmentation techniques to help describe our most deprived areas.

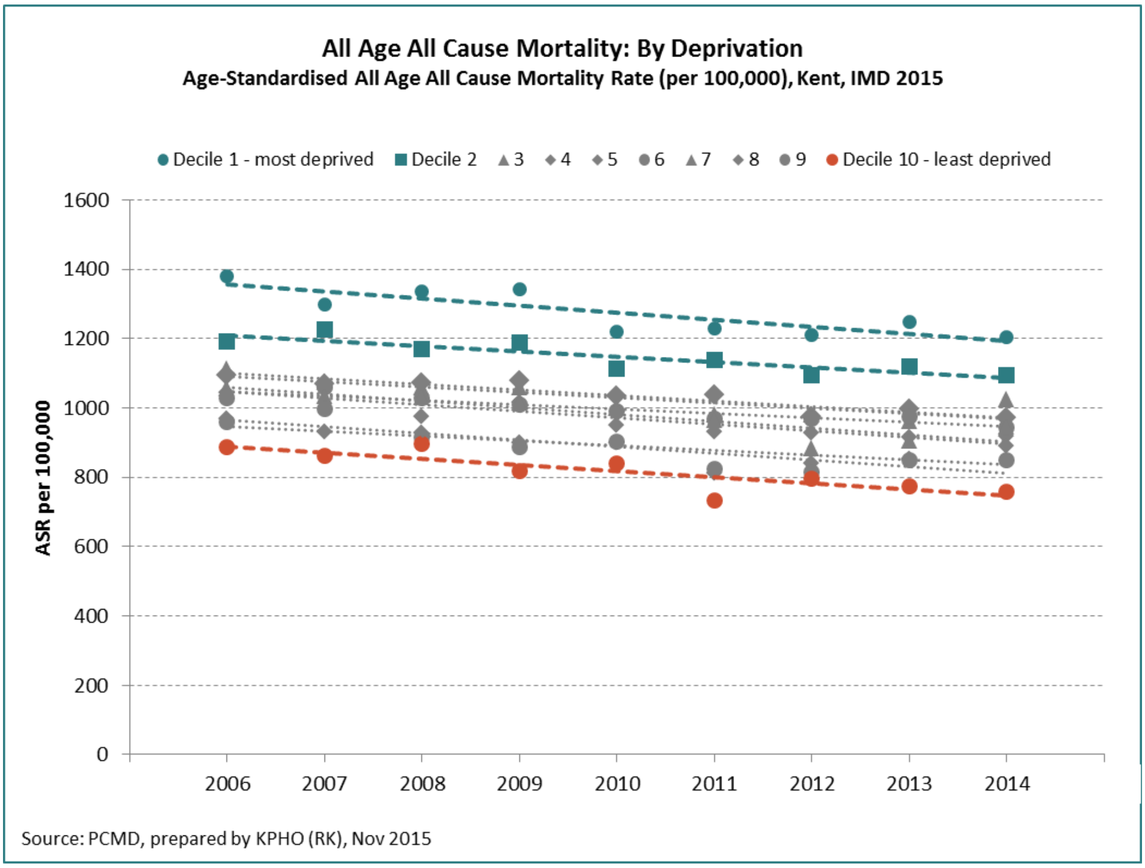
This analytical report describes the analysis we conducted and details the key findings. It should be read in conjunction with the 2015 Public Health Annual Report and the Mind The Gap: Health Inequalities Action Plan for Kent 2016 which it informs.

[2] Kent County Council. Mind The Gap: Kent's Health Inequalities Action Plan 2012/15. 2012:1-62
[3] Kent County Council. Kent Annual Public Health Report 2015: Health Inequalities (http://www.kpho.org.uk/__data/assets/pdf_file/0005/57407/Final-Public-Health-Annual-Report-2015.pdf).
[4] Kent County Council. Mind The Gap: Health Inequalities Action Plan for Kent 2016. Due for publication following County Council on 15th September 2016.

3. Inequalities in mortality & life expectancy

3.1 Trends in health inequalities

The chart below shows how the differences in all age, all cause mortality rates in Kent by deprivation decile have changed over time[5].



This analysis demonstrates that, whilst mortality rates in Kent have been falling over the last decade, the ‘gap’ in mortality rates between the most deprived and least deprived persists. The gap is particularly large for the most deprived deciles. This demonstrates how improving the health of an entire population does not necessarily address the health inequalities that exist between different parts of society. This persistent gap in health outcomes is not a phenomenon that is unique to Kent; the ONS recently reported that there has been a persistent fixed gap in the life expectancy across England as a whole[6]. This is consistent with the latest findings from the Global Burden of Disease Study[7]: that there are marked health

[5] In this analysis deprivation is measured via the Indices of Multiple Deprivation (IMD 2015) at LSOA-level, with the 902 LSOAs in Kent divided into population weighted deciles based on the overall IMD scores.

[6] Office for National Statistics. Statistical Bulletin Health Expectancies at birth by Middle Layer Super Output Areas , England , Inequality in Health and Life Expectancies within Upper Tier Local Authorities : 2009 to 2013. 2015:1-22.

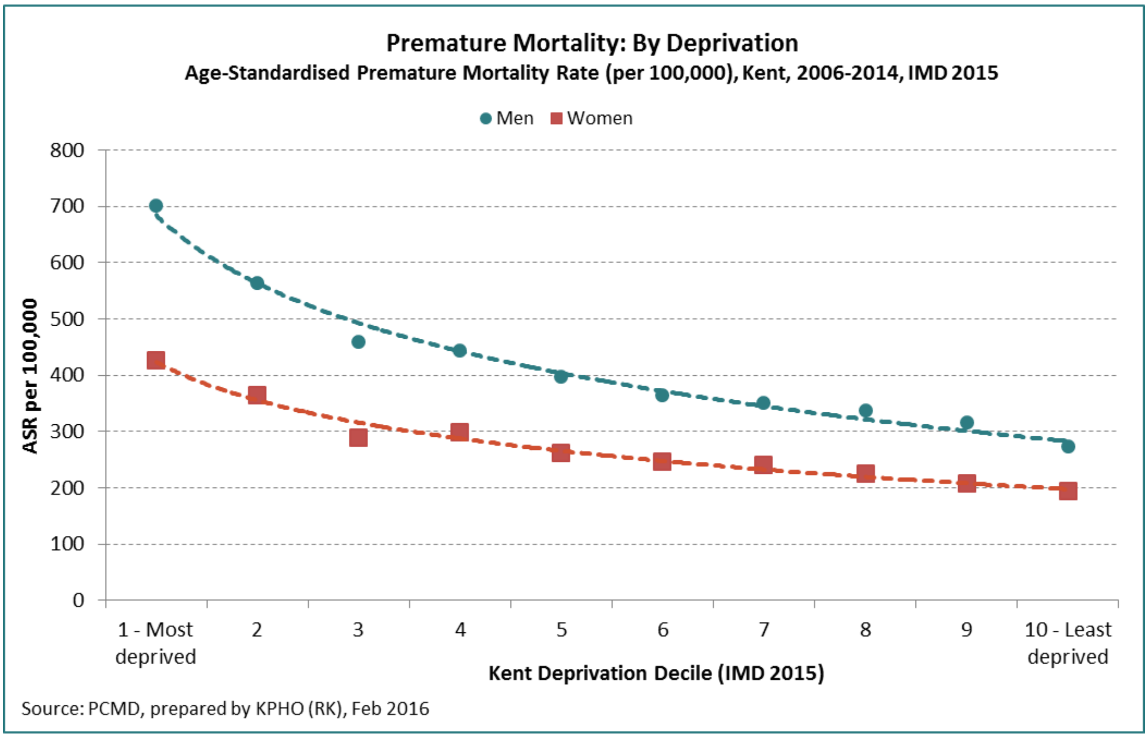
[7] Newton JN, Briggs ADM, Murray CJL, et al. Changes in health in England, with analysis by English regions and areas of deprivation , 1990 – 2013 : a systematic analysis for the Global Burden of Disease Study 2013. Lancet.

inequalities between the most and least deprived in England despite increases in overall life expectancy.

3.2 Inequality slopes

Health inequalities lead to inequalities in life expectancy. The analysis below looks both at life expectancy and premature mortality (deaths occurring under the age of 75 years) as it is these early deaths which lead to shorter life expectancy.

3.2.1 Premature mortality



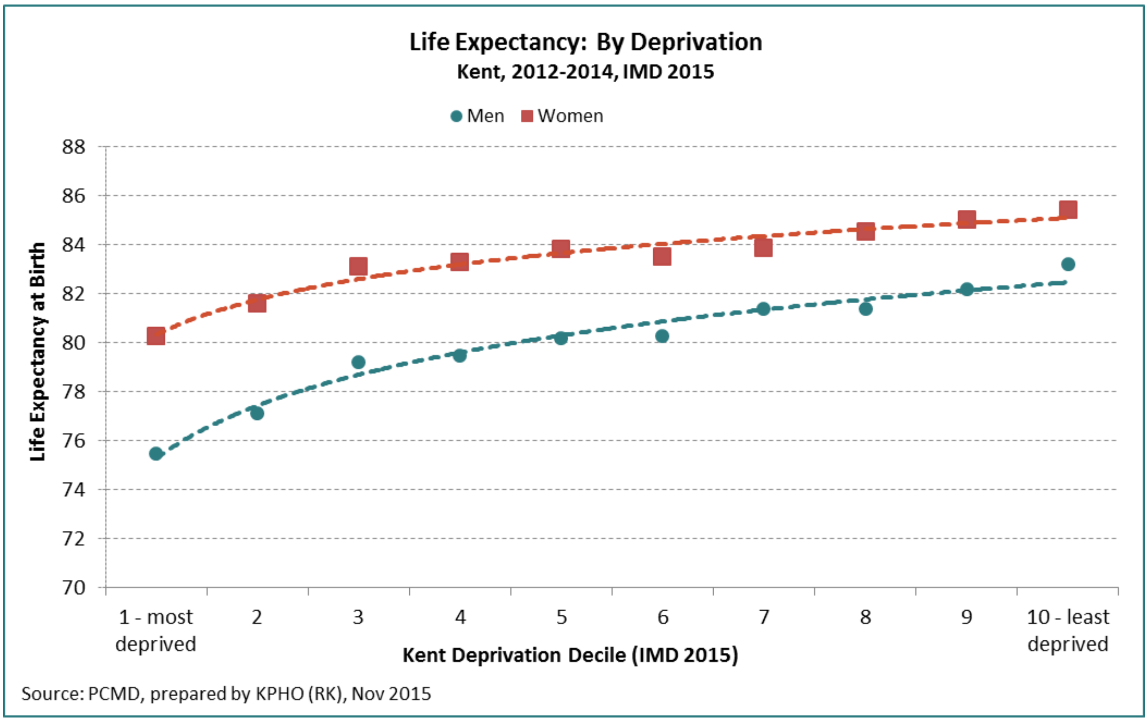
It is notable that the most deprived populations have disproportionately worse premature mortality, demonstrated by the non-linear curves of best-fit[8]. The most deprived decile in both men and women fare particularly poorly. In fact, in the most deprived decile, the premature mortality rate is more than double the rate in the most affluent decile.

In this analysis logarithmic trend lines have been used. It is clear from visual inspection alone that the relationship between deprivation and premature mortality is non-linear. In particular, the deviations from a linear trend line are clearly systematic in nature for the most deprived deciles. In the case of premature mortality the logarithmic trend lines for men and women have R^2 values of 99% and 98% respectively (compared with 86% and 87% for a linear trend line).

[8] Based on logarithmic trend lines.

3.2.2 Life expectancy

The chart below shows a similar analysis for life expectancy at birth.

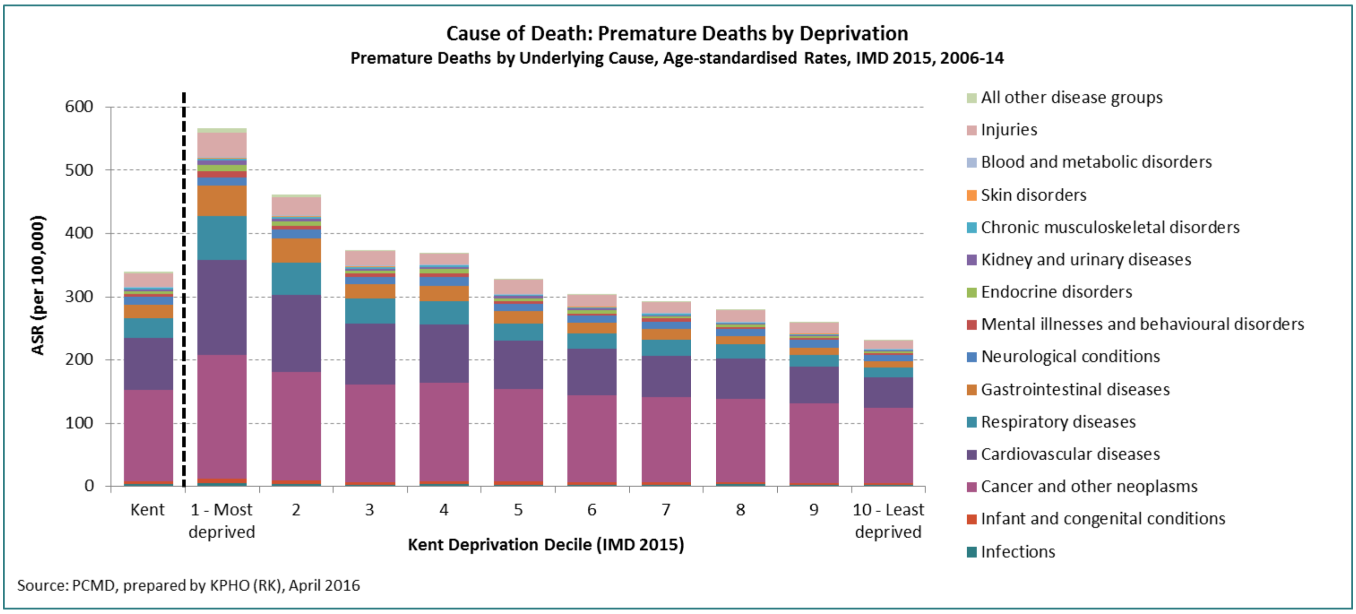


Again, the most deprived populations have disproportionately worse life expectancy, demonstrated by non-linear curves of best-fit. The most deprived decile in both men and women fare particularly poorly.

As with premature mortality, it is clear from visual inspection alone that the relationship between deprivation and life expectancy is non-linear. In particular, the deviations from a linear trend line are clearly systematic in nature for the most deprived deciles. In the case of premature mortality the logarithmic trend lines for men and women have R^2 values of 95% and 97% respectively (compared with 87% and 92% for a linear trend line).

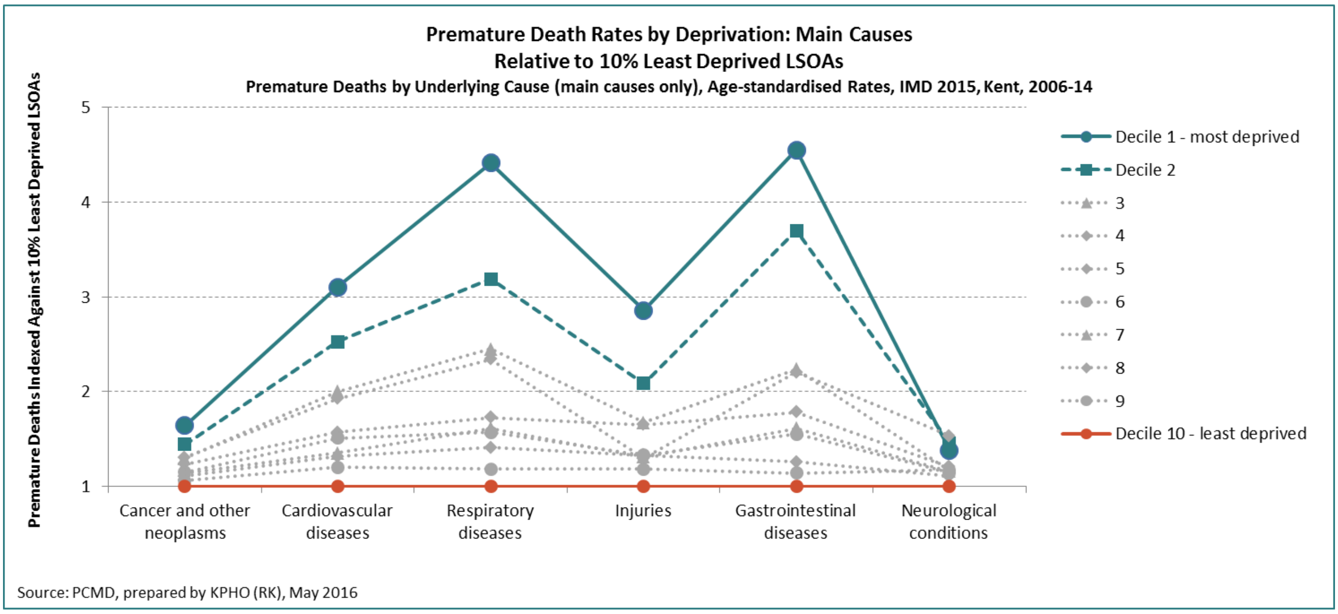
3.3 Causes of death

The chart below provides further analysis of premature deaths by deprivation in the context of cause of death.



This analysis not only demonstrates the higher rate of premature deaths in the most deprived deciles but also differences in the causes of premature mortality.

Cancer is the largest cause of premature mortality overall. But in the more deprived deciles, an increasing proportion of the deaths are caused by cardiovascular, respiratory and GI disease. This is demonstrated more clearly in the chart below, which indexes cause-specific premature mortality rates against the least deprived decile.



This analysis very clearly demonstrates the inequalities in the causes of premature mortality. In particular, it highlights striking differences in cardiovascular disease, respiratory disease, GI disease and external injuries. This is an important finding, since these inequalities are amenable to being reduced through earlier detection and preventative measures, such as lifestyle modification and management of long term health risks.

4. Inequalities in the wider determinants of health

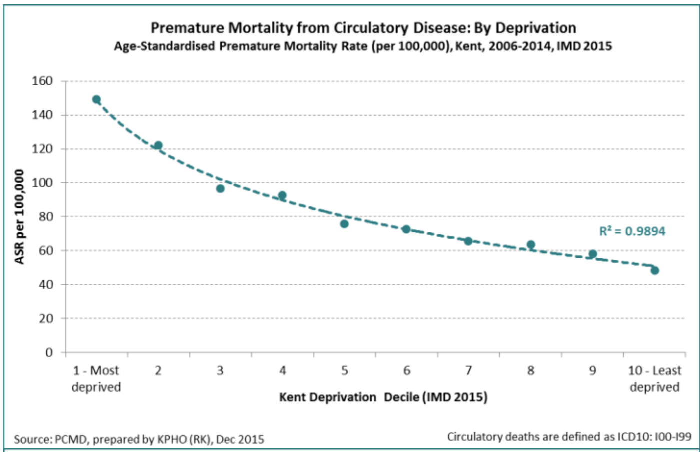
Given the inequalities in mortality rates and life expectancy, we would expect to see inequalities evident in the wider determinants of health. In this section we explore the relationship between deprivation and a range of measures of health outcomes, health risks and behaviours and the wider determinants of health. This analysis is again based on LSOA-level deprivation, with LSOAs grouped into deciles, and so requires LSOA-level data for each of the wider determinants. Analysis has been conducted for known social determinants of health, for which data exists or can be modelled at LSOA level[9].

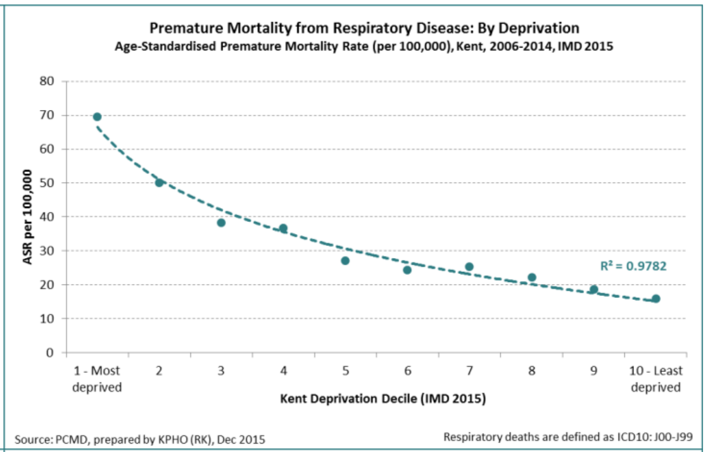
The charts overleaf show inequality slopes for a range of health outcome measures, measures of health risks and behaviours, and wider determinants of health.

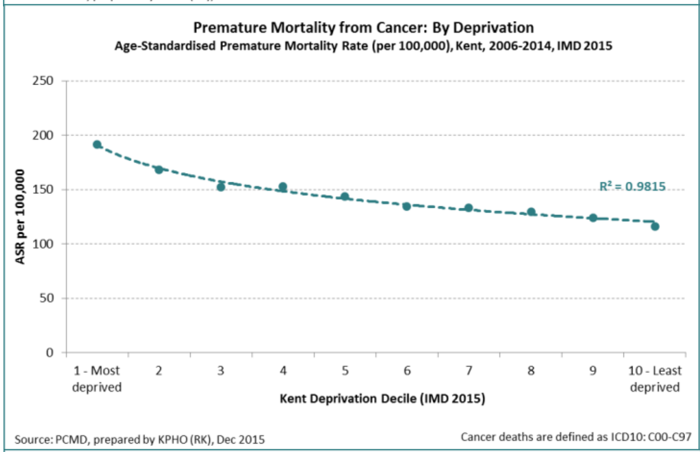
It is striking how steep inequality gradients are evident across a large number of health and social indicators in Kent. For example, in the most deprived decile, 66% of children do not achieve 5 good GCSEs, compared to 23% in the most affluent decile. Taking all the charts together, it is clear to see how poor social conditions and unhealthy behaviours reinforce one another and accumulate in individuals throughout their lives. Where the relationship is linear, those in the most deprived deciles fare worse than those in the least deprived deciles, to a degree that is proportionate to the slope of inequality. On many measures the gradient is not linear but rather curves sharply for the most deprived deciles. In these instances the most deprived deciles fare disproportionately worse than their more affluent counterparts. For example, alcohol-related premature mortality is six times higher in the most deprived decile than the most affluent decile.

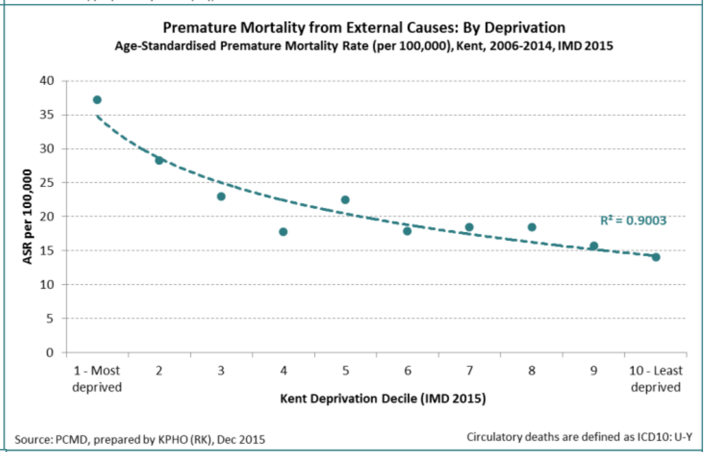
[9] Appendix A provides details of the data sources and modelling approaches.

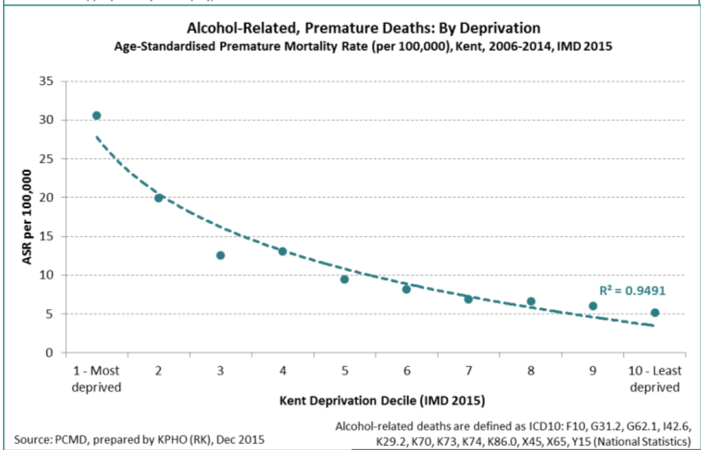
4.1 Inequality slopes: Health outcomes

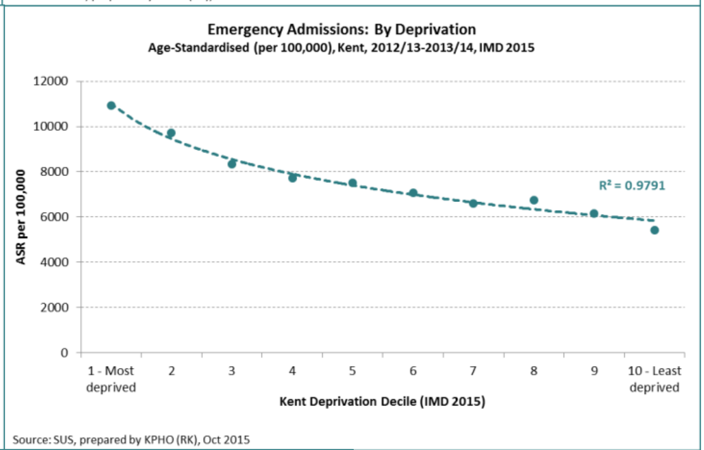


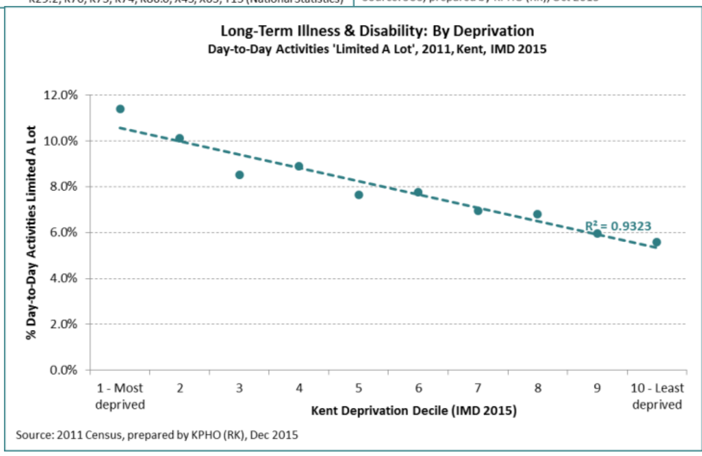




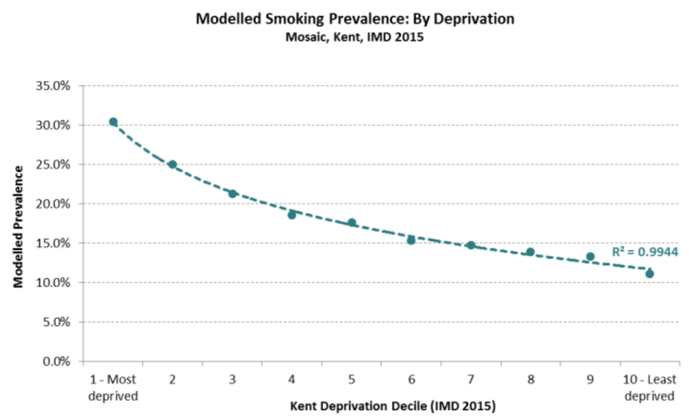




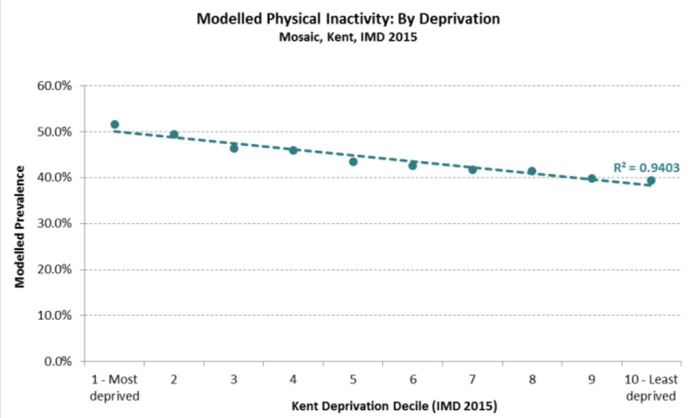




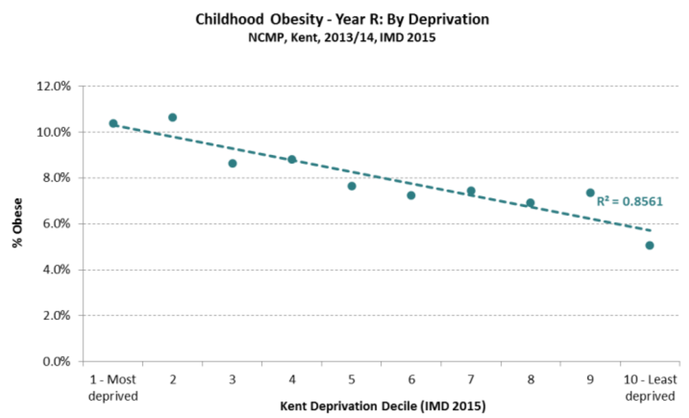
4.2 Inequality slopes: Health risks & behaviours



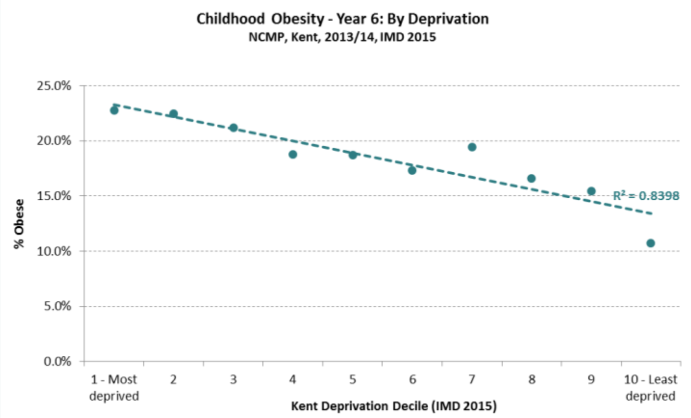
Source: Experian, prepared by KPHO (RK), Dec 2015



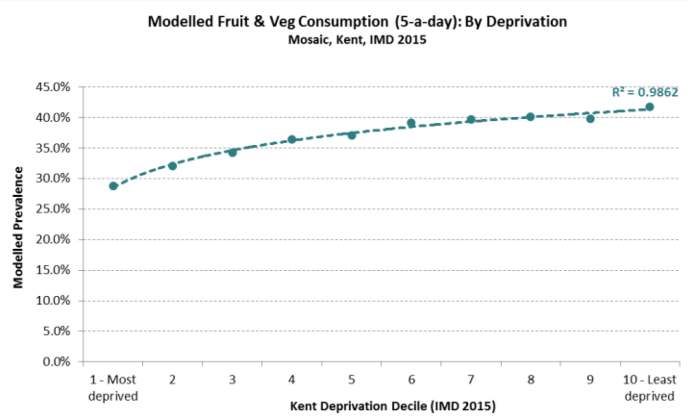
Source: Experian, prepared by KPHO (RK), Dec 2015



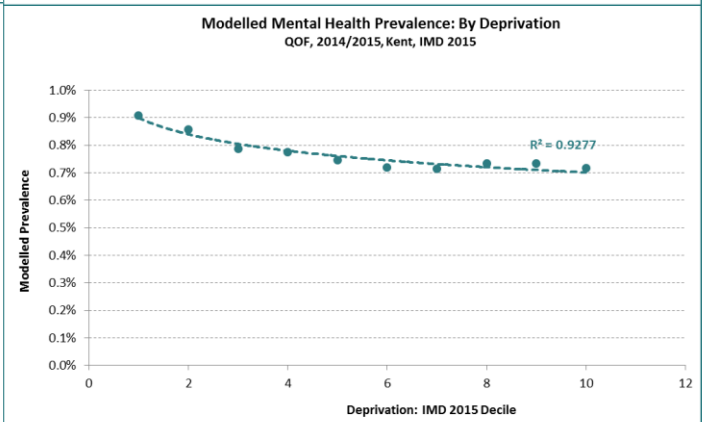
Source: NCMP, prepared by KPHO (RK), June 2016



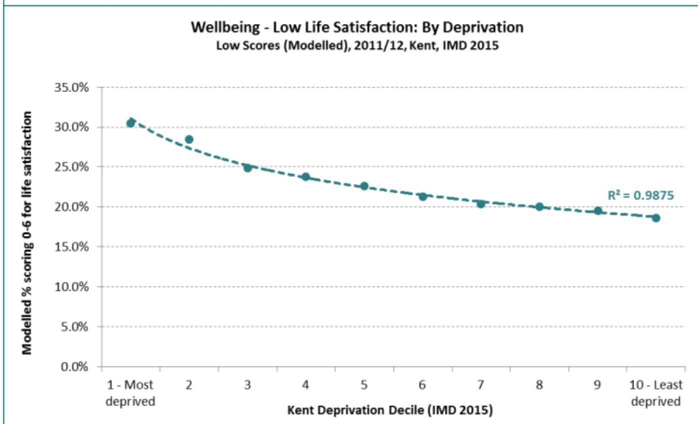
Source: NCMP, prepared by KPHO (RK), Dec 2015



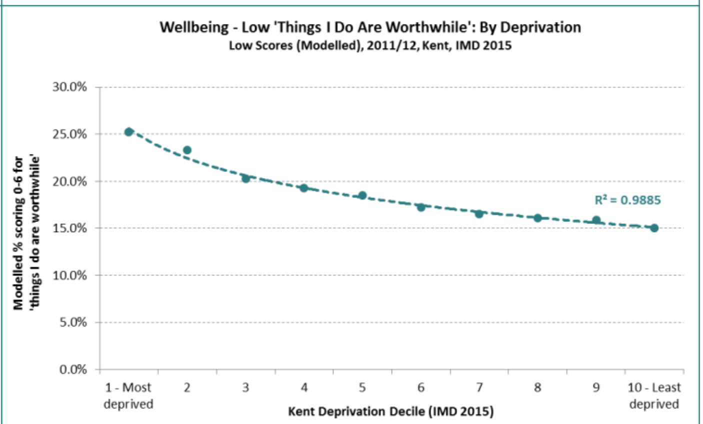
Source: Experian, prepared by KPHO (RK), Dec 2015



Source: QOF, prepared by KPHO (RK), Jan 2016

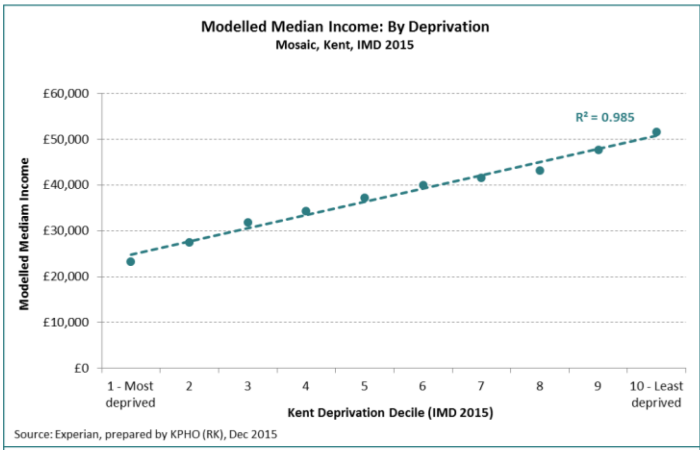


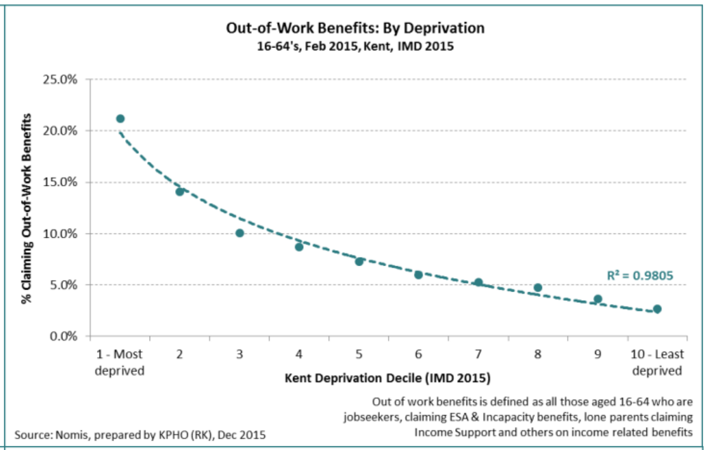
Source: DCLG (ONS Annual Population Survey (APS) data and Acorn), prepared by KPHO (RK), Dec 2015

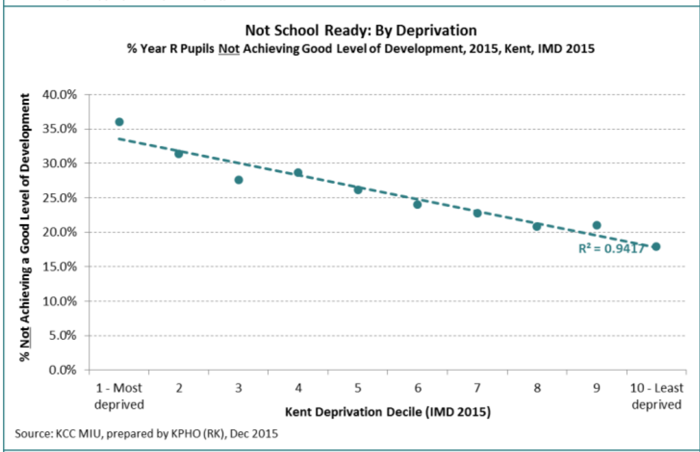


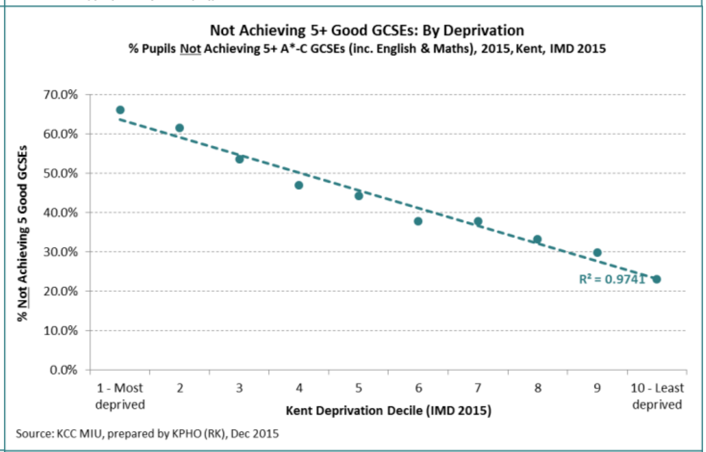
Source: DCLG (ONS Annual Population Survey (APS) data and Acorn), prepared by KPHO (RK), Dec 2015

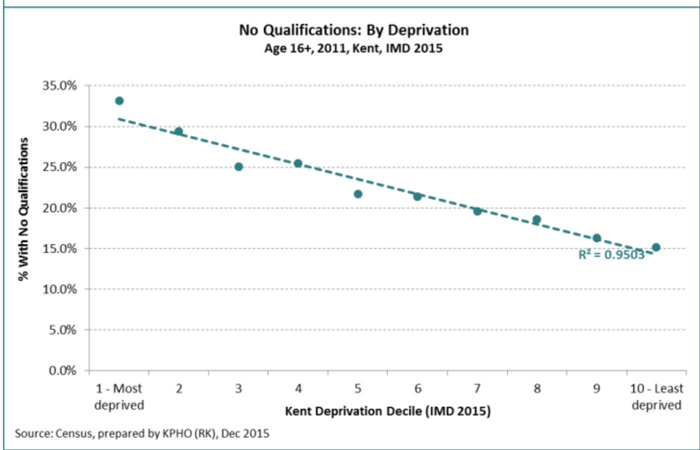
4.3 Inequality slopes: Wider determinants of health

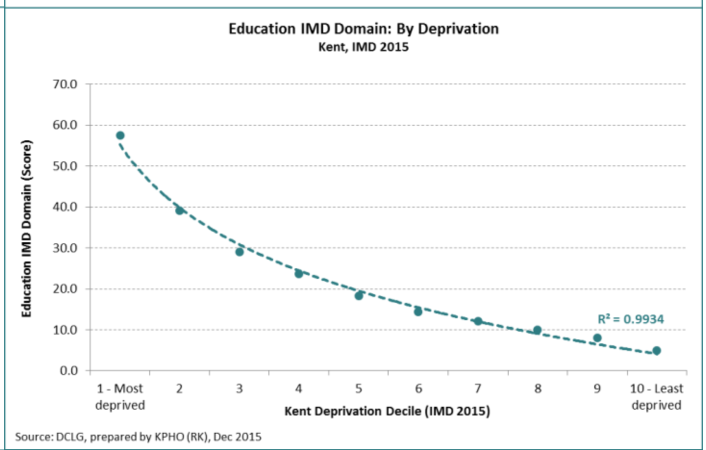


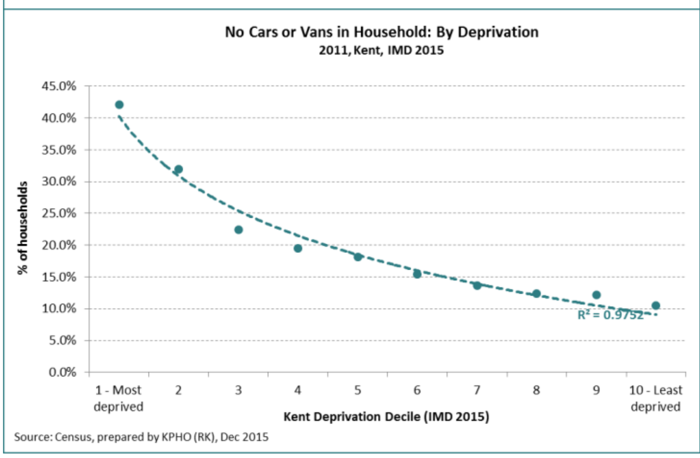


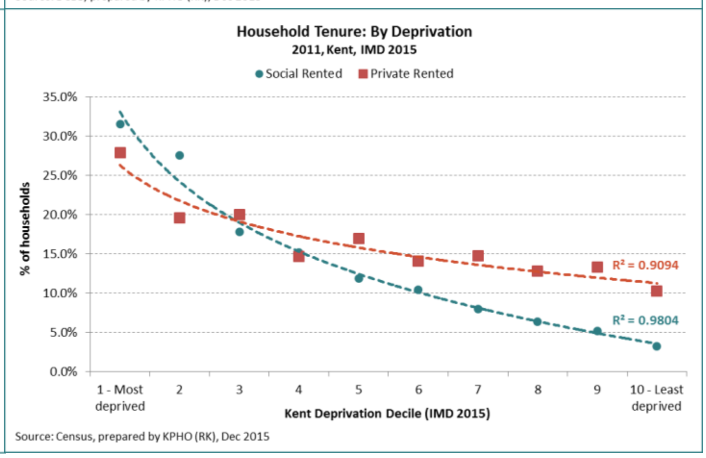


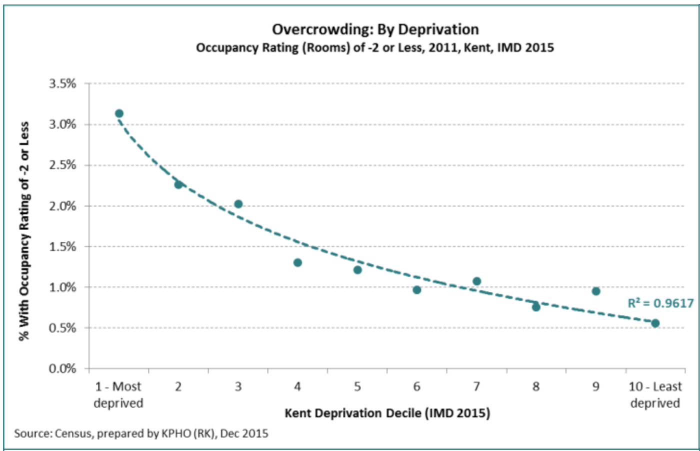


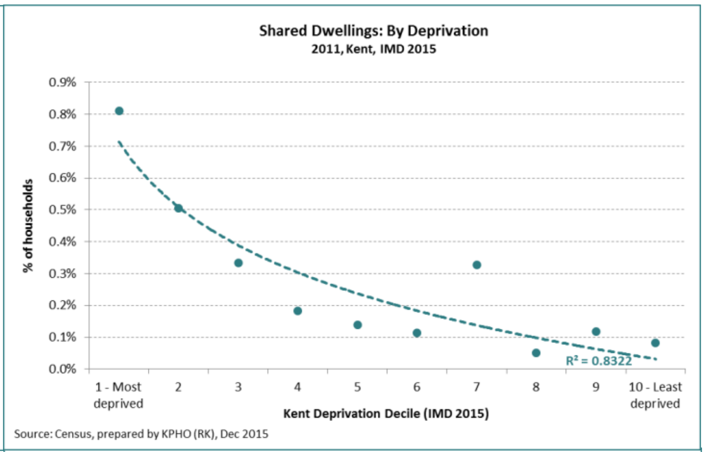


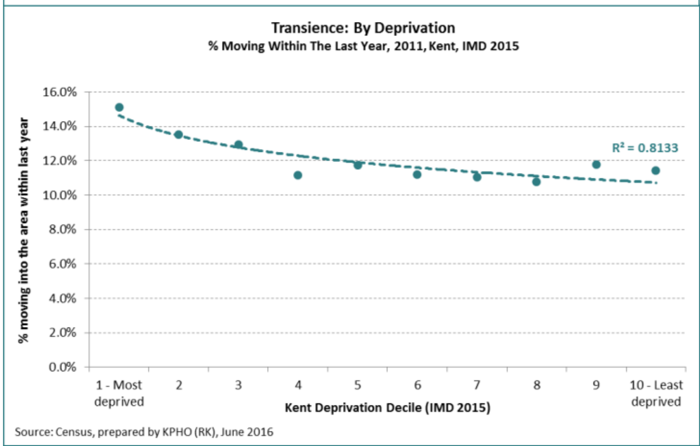


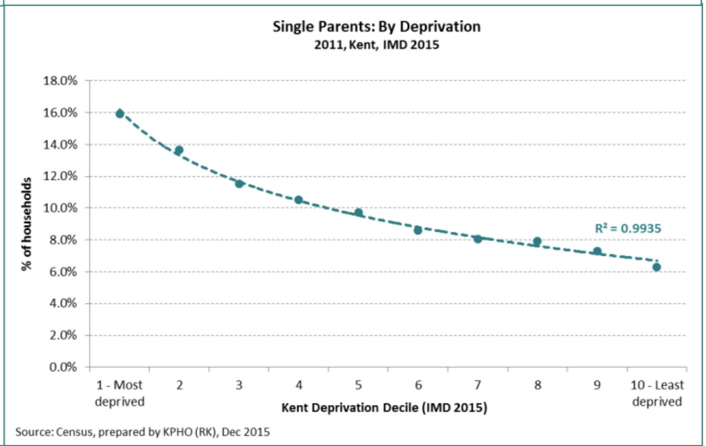


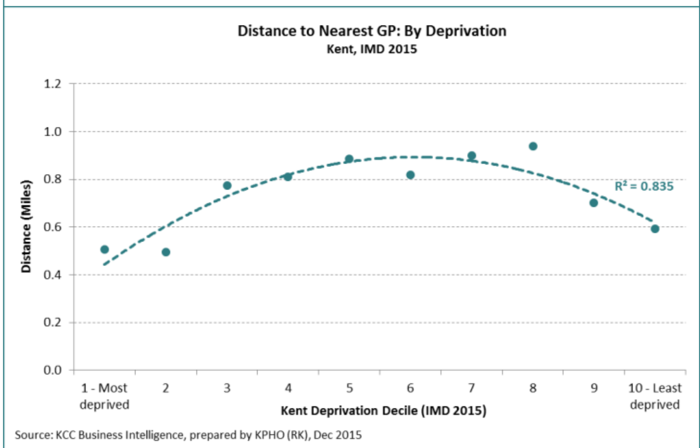


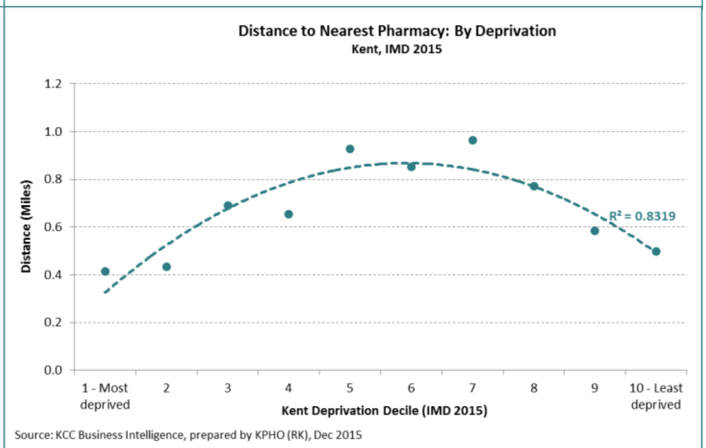

Overcrowding: By Deprivation
Occupancy Rating (Rooms) of -2 or Less, 2011, Kent, IMD 2015
% With Occupancy Rating of -2 or Less
R² = 0.9617
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: Census, prepared by KPHO (RK), Dec 2015

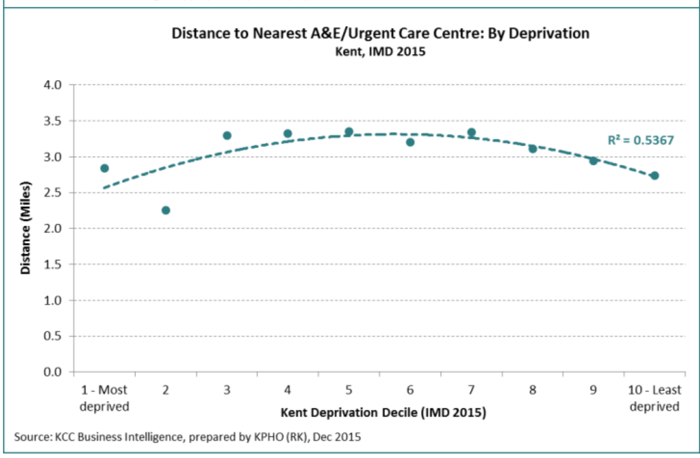

Shared Dwellings: By Deprivation
2011, Kent, IMD 2015
% of households
R² = 0.8322
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: Census, prepared by KPHO (RK), Dec 2015

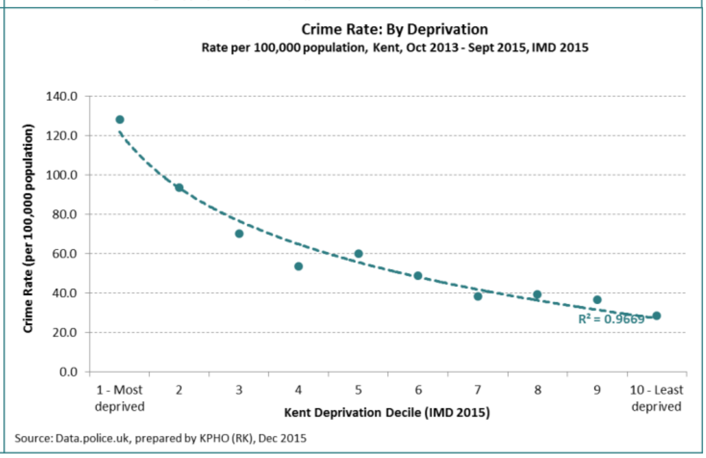

Transience: By Deprivation
% Moving Within The Last Year, 2011, Kent, IMD 2015
% moving into the area within last year
R² = 0.8133
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: Census, prepared by KPHO (RK), June 2016

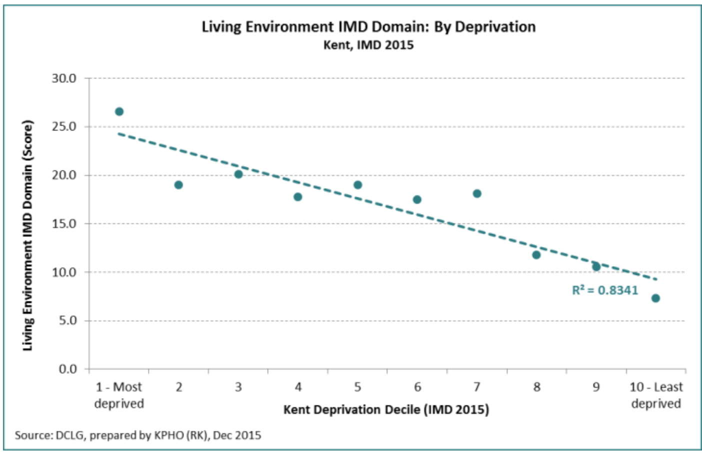

Single Parents: By Deprivation
2011, Kent, IMD 2015
% of households
R² = 0.9935
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: Census, prepared by KPHO (RK), Dec 2015

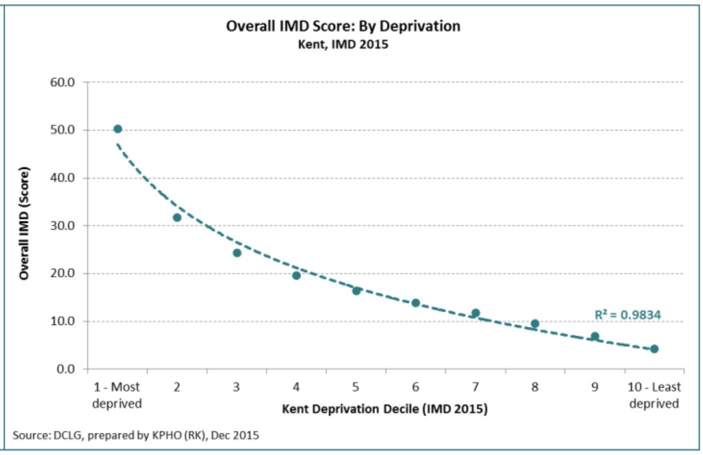

Distance to Nearest GP: By Deprivation
Kent, IMD 2015
Distance (Miles)
R² = 0.835
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: KCC Business Intelligence, prepared by KPHO (RK), Dec 2015


Distance to Nearest Pharmacy: By Deprivation
Kent, IMD 2015
Distance (Miles)
R² = 0.8319
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: KCC Business Intelligence, prepared by KPHO (RK), Dec 2015


Distance to Nearest A&E/Urgent Care Centre: By Deprivation
Kent, IMD 2015
Distance (Miles)
R² = 0.5367
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: KCC Business Intelligence, prepared by KPHO (RK), Dec 2015


Crime Rate: By Deprivation
Rate per 100,000 population, Kent, Oct 2013 - Sept 2015, IMD 2015
Crime Rate (per 100,000 population)
R² = 0.9669
1 - Most deprived
10 - Least deprived
Kent Deprivation Decile (IMD 2015)
Source: Data.police.uk, prepared by KPHO (RK), Dec 2015





5. Types of deprivation

The above analysis clearly identifies the populations of the areas falling into the most deprived decile in Kent as suffering from disproportionately poor health outcomes and being disproportionately likely to display a number of characteristics associated with poor health outcomes. Before we can improve health outcomes in the most deprived areas, we need to gain deeper insights into the characteristics of the populations and the challenges they face.

The analysis in this section attempts to address concerns relating to treating the most deprived decile as a single homogenous group. Within this decile different local areas will face different challenges and so potentially require different interventions and approaches. However, it was our hypothesis that there exists some degree of commonality between certain groups of LSOAs falling into the most deprived decile.

5.1 Segmentation

The 88 LSOAs identified as falling into the most deprived decile have been subdivided using multivariate segmentation techniques. This segmentation seeks to divide the most deprived LSOAs into 'types', so that within a 'type' areas are similar and between 'types' they differ. Mosaic[10] has been used as the basis for the segmentation.

SPSS was used to run a k-means cluster analysis, which has identified relatively homogeneous groups of LSOAs based on their Mosaic profiles. The method allowed iterative identification of cluster centres. The 4-cluster solution was selected as the most

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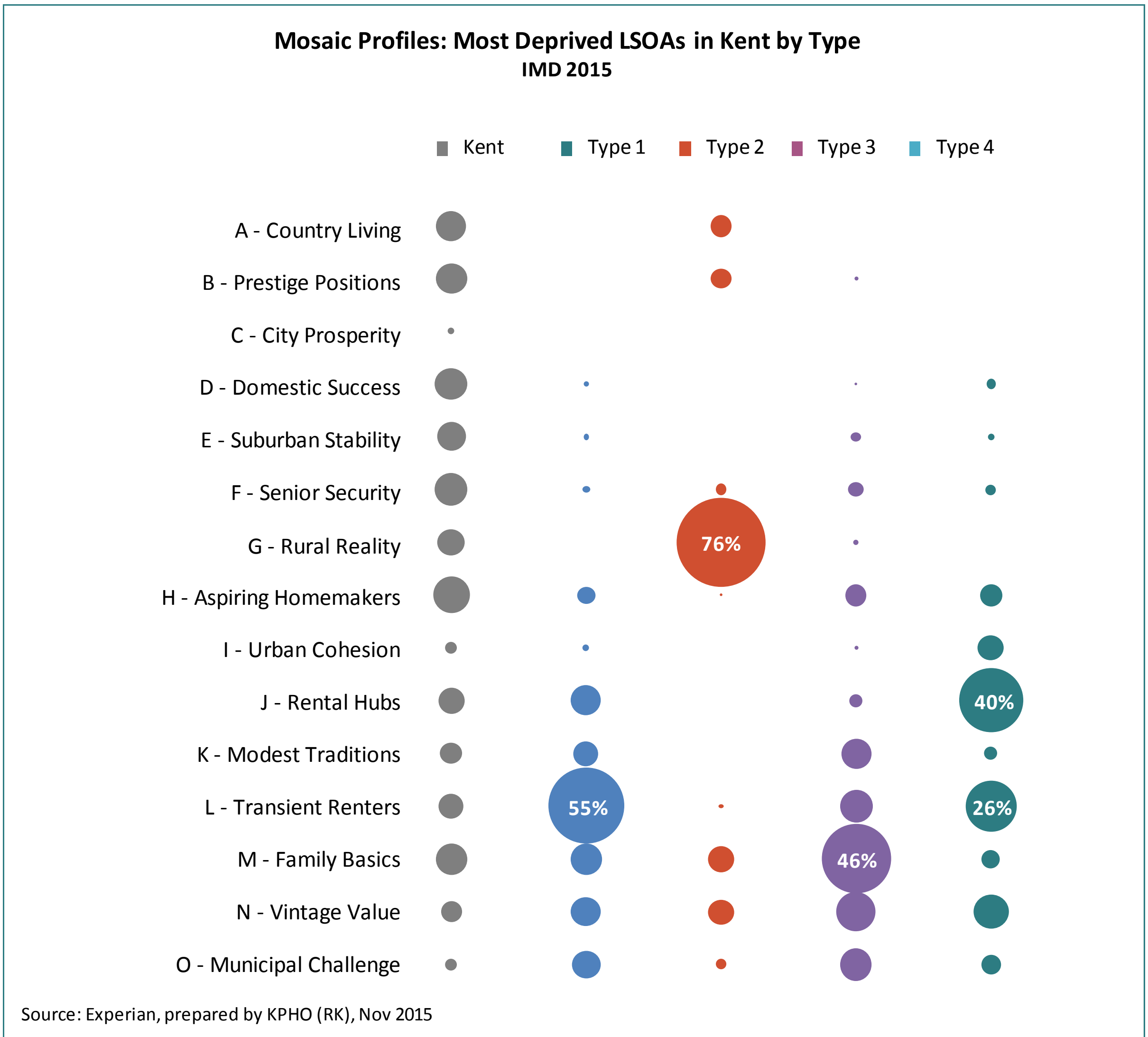
[10] MOSAIC is a population segmentation tool produced by Experian, which is increasingly being used in the public sector to better understand local populations. The classification system draws upon 450 different sources of data relating to socio-demographics, lifestyle, culture and behaviour, and then categorises households based on this.

appropriate, with the clusters labelled 'Type 1', 'Type 2', 'Type 3' and 'Type 4'. Appendix C gives a full listing of the type allocated to each of the 88 LSOAs falling within Kent's most deprived decile.

Based on the detailed analysis contained later within this section, the clusters were given names as follows:

- Type 1: Young people lacking opportunities
- Type 2: Deprived rural households
- Type 3: Families in social housing
- Type 4: Young people in poor quality accommodation.

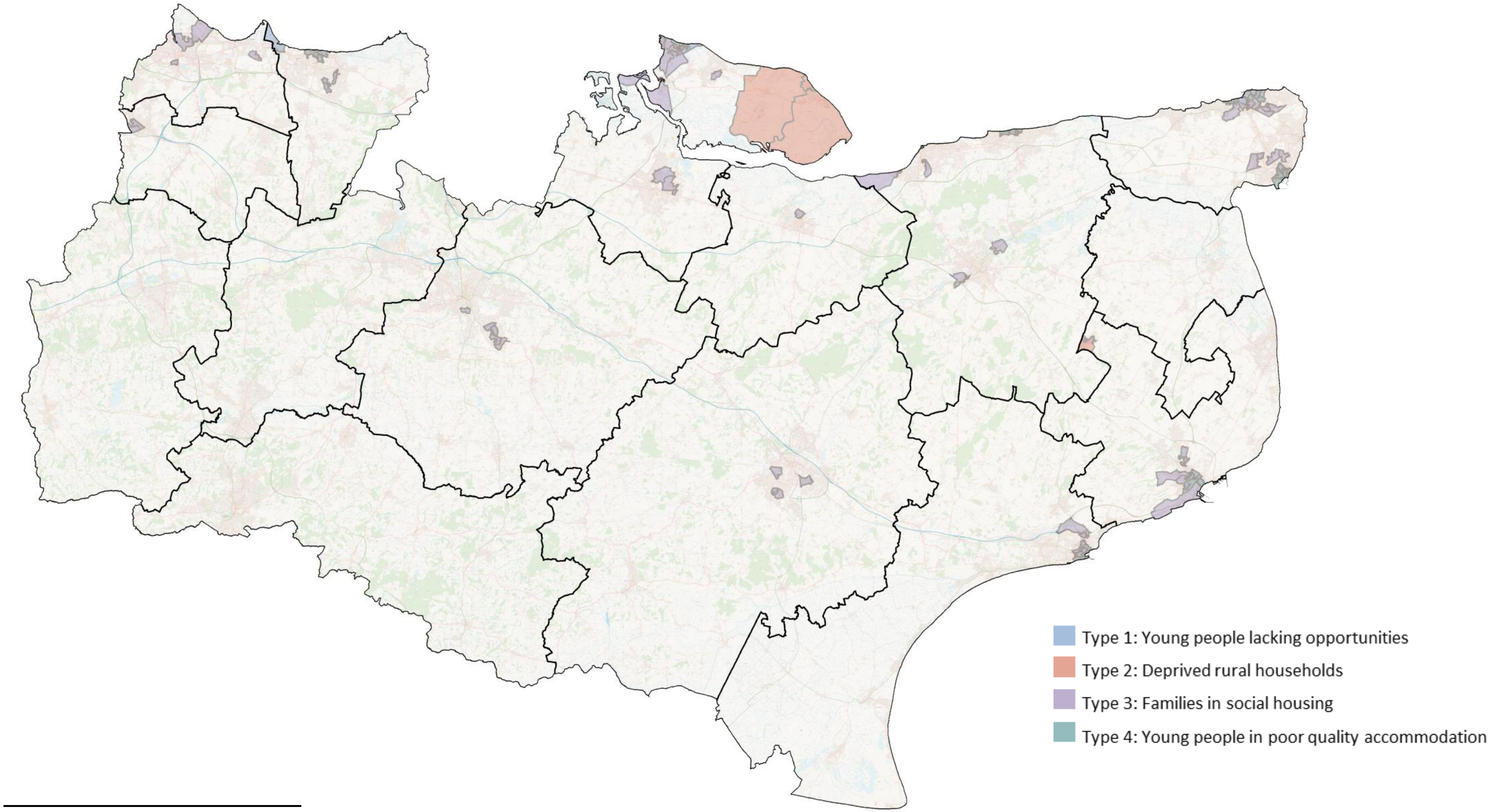
The chart below shows the Mosaic profiles of each of the four types.



There are clear differences between the four deprivation types in respect of their Mosaic profiles.

The map below shows Kent's most deprived decile LSOAs by type[11].

Most Deprived Decile LSOAs in Kent: By Deprivation Type

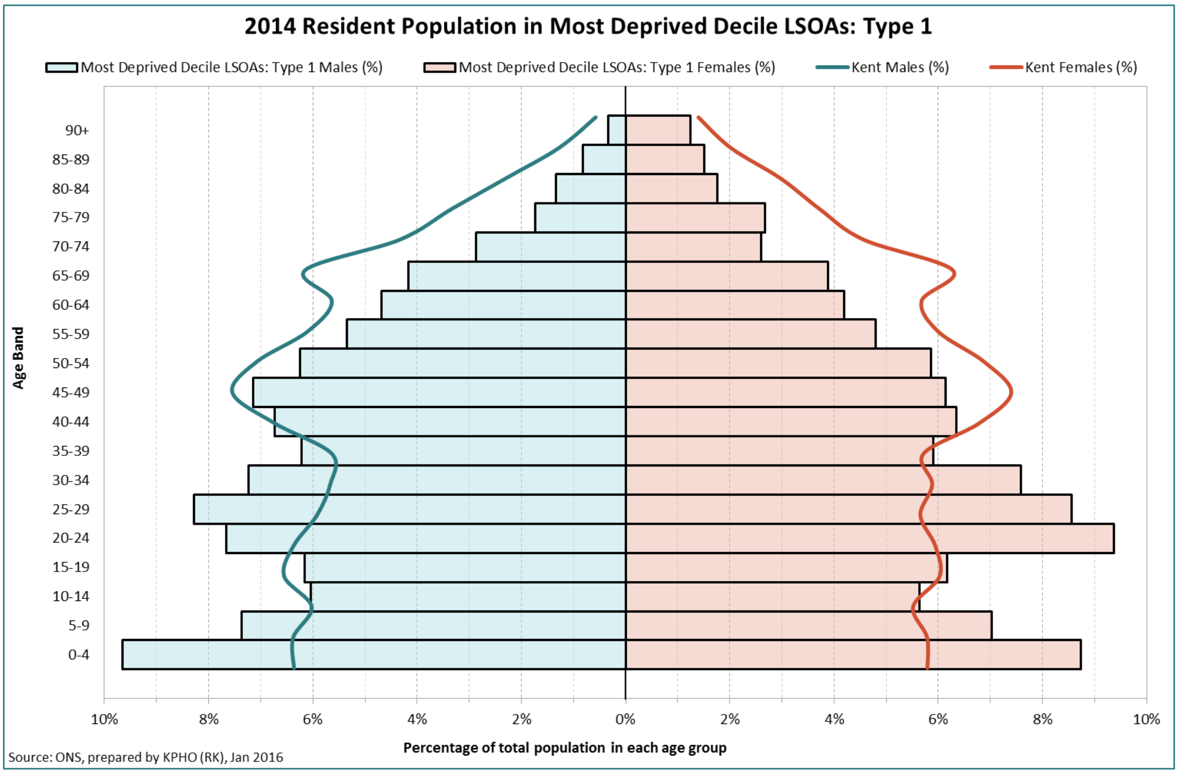


[11] More detailed local maps can be found in the CCG-level summaries contained within Appendix B.

5.2 Type 1: Young people lacking opportunities

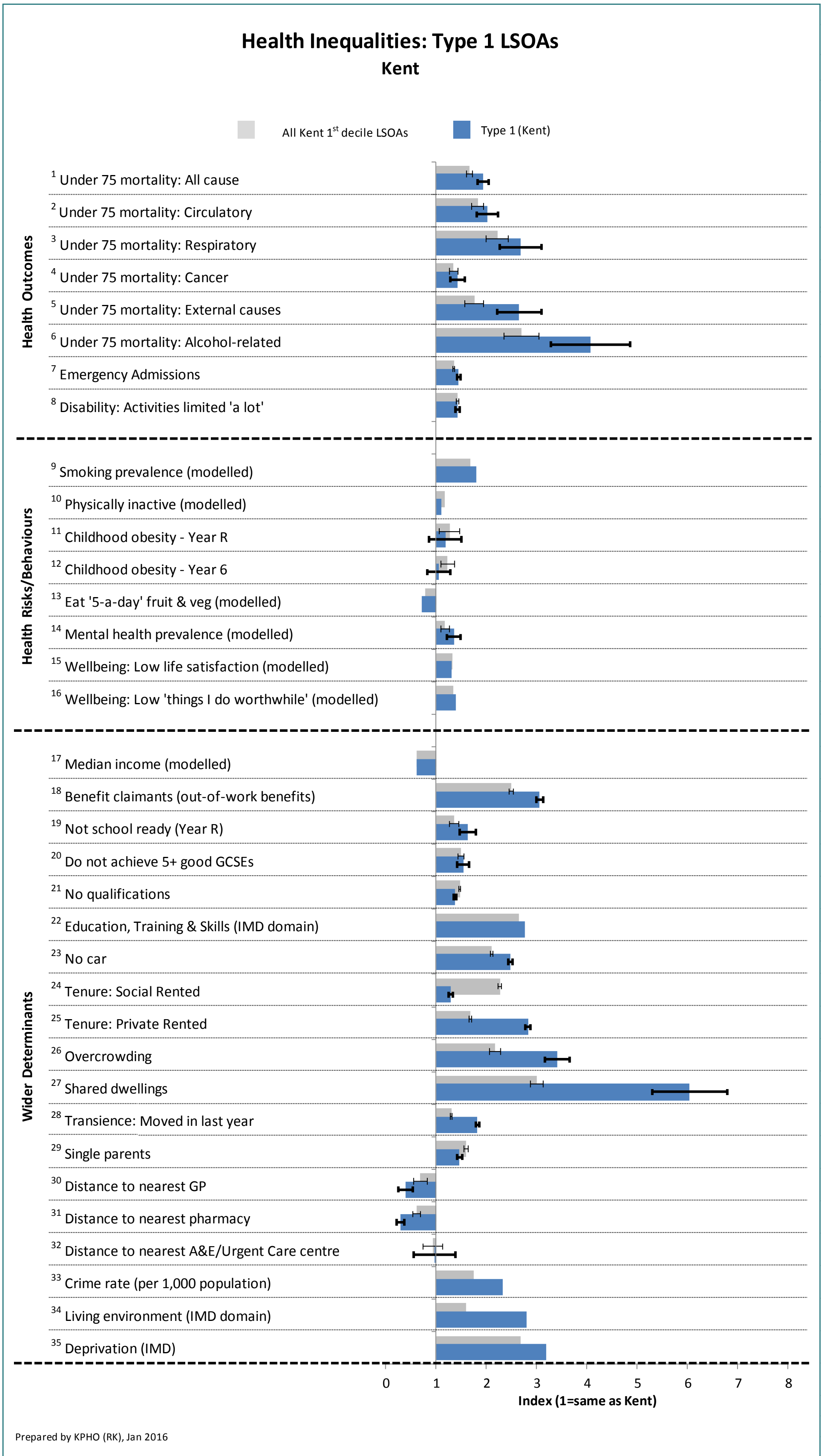
A total of 18 of the 88 most deprived decile LSOAs in Kent fall into type 1. These include LSOAs in Northfleet, Folkestone Harbour, Clarendon, Tower Hamlets, Sheerness East Margate Central, Cliftonville West and Eastcliff. For detailed local maps of the individual LSOAs falling into this cluster see the CCG-level summaries in Appendix B.

The chart below shows the age structure of the population of type 1 deprived areas in comparison with Kent as a whole.



This analysis shows that type 1 deprived areas have high numbers of young adults and of young children.

The chart overleaf provides a summary of the characteristics of type 1 deprived areas in terms of health outcomes, health risks and behaviours, and the wider determinants of health. In this analysis type 1 deprived areas have been indexed against the average for Kent for each individual characteristic. Also shown is data for the most deprived decile as a whole. For details of the data sources used for each characteristic see Appendix A.


Health Inequalities: Type 1 LSOAs
Kent
All Kent 1st decile LSOAs
Type 1 (Kent)
Health Outcomes
1 Under 75 mortality: All cause
2 Under 75 mortality: Circulatory
3 Under 75 mortality: Respiratory
4 Under 75 mortality: Cancer
5 Under 75 mortality: External causes
6 Under 75 mortality: Alcohol-related
7 Emergency Admissions
8 Disability: Activities limited 'a lot'
Health Risks/Behaviours
9 Smoking prevalence (modelled)
10 Physically inactive (modelled)
11 Childhood obesity - Year R
12 Childhood obesity - Year 6
13 Eat '5-a-day' fruit & veg (modelled)
14 Mental health prevalence (modelled)
15 Wellbeing: Low life satisfaction (modelled)
16 Wellbeing: Low 'things I do worthwhile' (modelled)
Wider Determinants
17 Median income (modelled)
18 Benefit claimants (out-of-work benefits)
19 Not school ready (Year R)
20 Do not achieve 5+ good GCSEs
21 No qualifications
22 Education, Training & Skills (IMD domain)
23 No car
24 Tenure: Social Rented
25 Tenure: Private Rented
26 Overcrowding
27 Shared dwellings
28 Transience: Moved in last year
29 Single parents
30 Distance to nearest GP
31 Distance to nearest pharmacy
32 Distance to nearest A&E/Urgent Care centre
33 Crime rate (per 1,000 population)
34 Living environment (IMD domain)
35 Deprivation (IMD)
0
1
2
3
4
5
6
7
8
Index (1=same as Kent)
Prepared by KPHO (RK), Jan 2016

Type 1 deprived areas are characterised by high numbers of young adults in private rented accommodation.

This analysis highlights the following key characteristics of type 1 deprived areas in respect of some of the wider determinants of health, and in comparison with Kent as a whole:

- Particularly high levels of shared dwellings and overcrowding
- Particularly poor living environment with particularly high crime rates
- Low incomes
- Particularly high levels of out-of-work benefit claimants
- Poor scores for education
- Particularly high levels of movement/transiency.

In terms of health risks and behaviours, type 1 deprived areas have:

- High smoking prevalence
- Low levels of wellbeing.

In terms of health outcomes, type 1 deprived areas have:

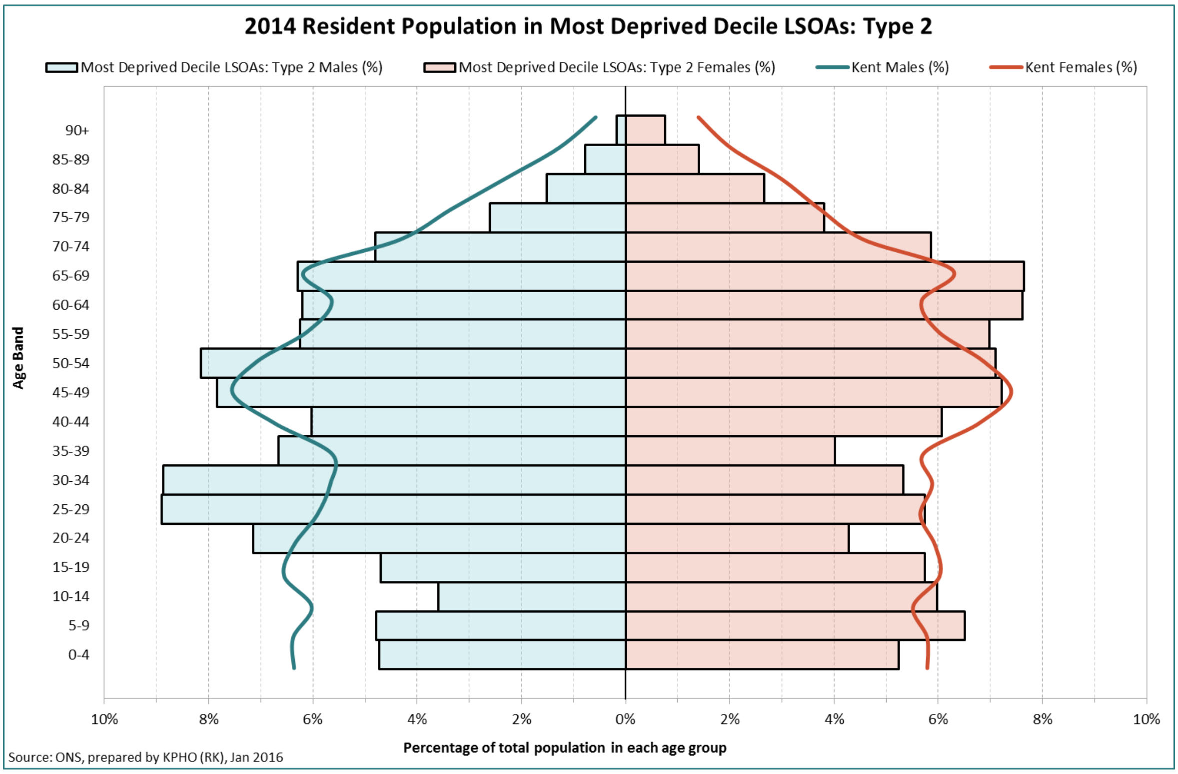
- Particularly high premature mortality rates, with alcohol-related premature mortality, premature mortality from ‘external causes’ particularly high
- High emergency hospital admission rates
- High rates of disability (‘activities limited a lot’).

Please see Appendix B for analysis of type 1 deprived areas at CCG-level, including detailed local maps for individual LSOAs falling into this cluster.

5.3 Type 2: Deprived rural households

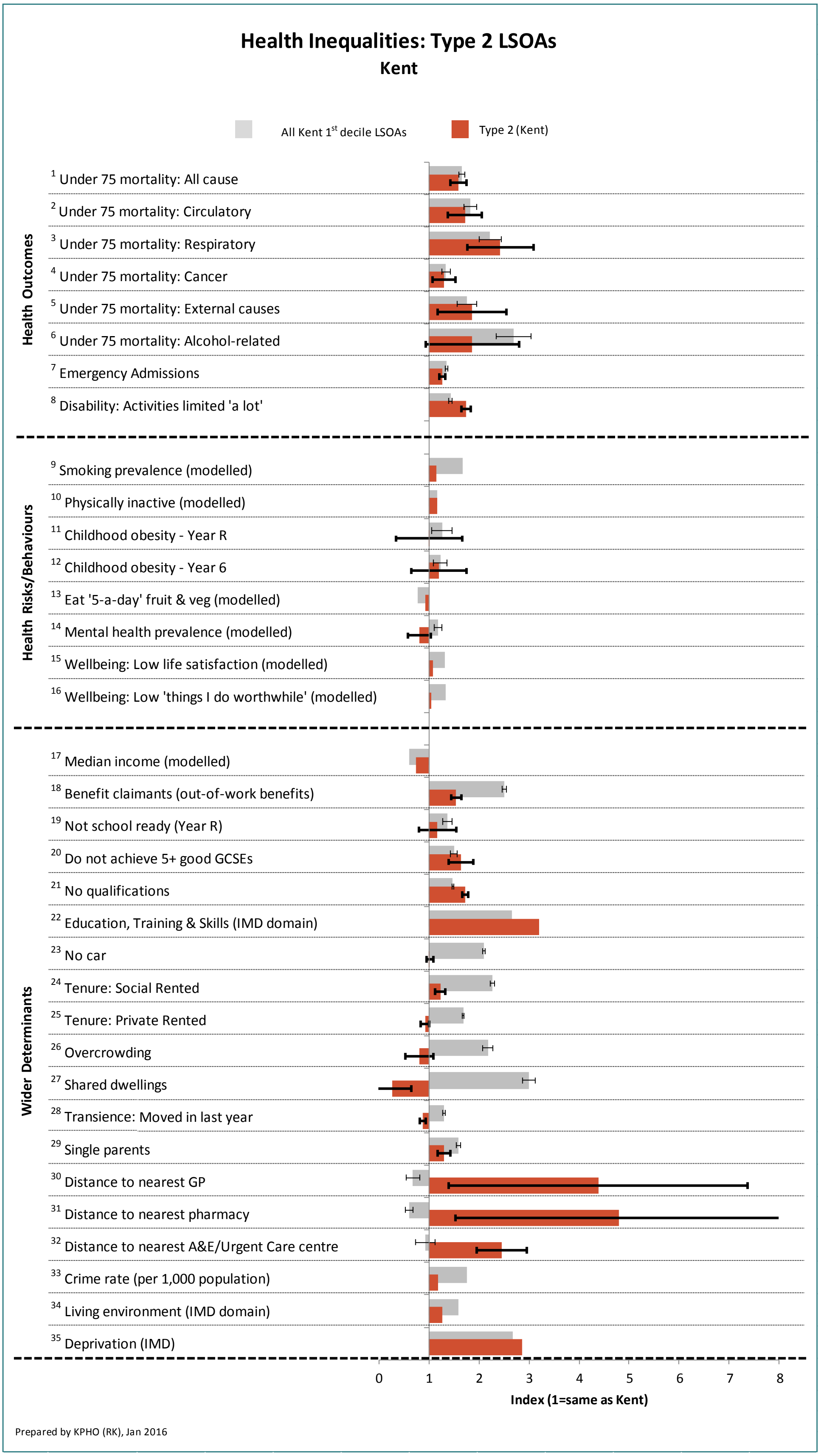
A total of 4 of the 88 most deprived decile LSOAs in Kent fall into type 2. These include LSOAs in Aylesham, Leysdown-On-Sea, Warden and Eastchurch. It must be borne in mind when interpreting the results for type 2 LSOAs that data is based on a relatively small population. For detailed local maps of the individual LSOAs falling into this cluster see the CCG-level summaries in Appendix B.

The chart below shows the age structure of the population of type 2 deprived areas in comparison with Kent as a whole.



This analysis shows that type 2 deprived areas have lower numbers of children than the Kent population as a whole (and other deprived area types).

The chart overleaf provides a summary of the characteristics of type 2 deprived areas in terms of health outcomes, health risks and behaviours, and the wider determinants of health. In this analysis type 2 deprived areas have been indexed against the average for Kent for each individual characteristic. Also shown is data for the most deprived decile as a whole.


Health Inequalities: Type 2 LSOAs
Kent
All Kent 1st decile LSOAs
Type 2 (Kent)
Health Outcomes
1 Under 75 mortality: All cause
2 Under 75 mortality: Circulatory
3 Under 75 mortality: Respiratory
4 Under 75 mortality: Cancer
5 Under 75 mortality: External causes
6 Under 75 mortality: Alcohol-related
7 Emergency Admissions
8 Disability: Activities limited 'a lot'
Health Risks/Behaviours
9 Smoking prevalence (modelled)
10 Physically inactive (modelled)
11 Childhood obesity - Year R
12 Childhood obesity - Year 6
13 Eat '5-a-day' fruit & veg (modelled)
14 Mental health prevalence (modelled)
15 Wellbeing: Low life satisfaction (modelled)
16 Wellbeing: Low 'things I do worthwhile' (modelled)
Wider Determinants
17 Median income (modelled)
18 Benefit claimants (out-of-work benefits)
19 Not school ready (Year R)
20 Do not achieve 5+ good GCSEs
21 No qualifications
22 Education, Training & Skills (IMD domain)
23 No car
24 Tenure: Social Rented
25 Tenure: Private Rented
26 Overcrowding
27 Shared dwellings
28 Transience: Moved in last year
29 Single parents
30 Distance to nearest GP
31 Distance to nearest pharmacy
32 Distance to nearest A&E/Urgent Care centre
33 Crime rate (per 1,000 population)
34 Living environment (IMD domain)
35 Deprivation (IMD)
0
1
2
3
4
5
6
7
8
Index (1=same as Kent)
Prepared by KPHO (RK), Jan 2016

This analysis highlights the following key characteristics of type 2 deprived areas in respect of some of the wider determinants of health, and in comparison with Kent as a whole:

- Low educational attainment and lack of qualifications
- Fewer out-of-work benefit claimants than other deprived groups
- Car ownership is high
- Lower crime rates than many other deprived areas
- Low levels of movement/transiency.

In terms of health risks and behaviours, type 2 deprived areas have:

- Lower smoking prevalence than other deprived area types
- Higher levels of wellbeing than other deprived area types.

In terms of health outcomes, type 2 deprived areas have:

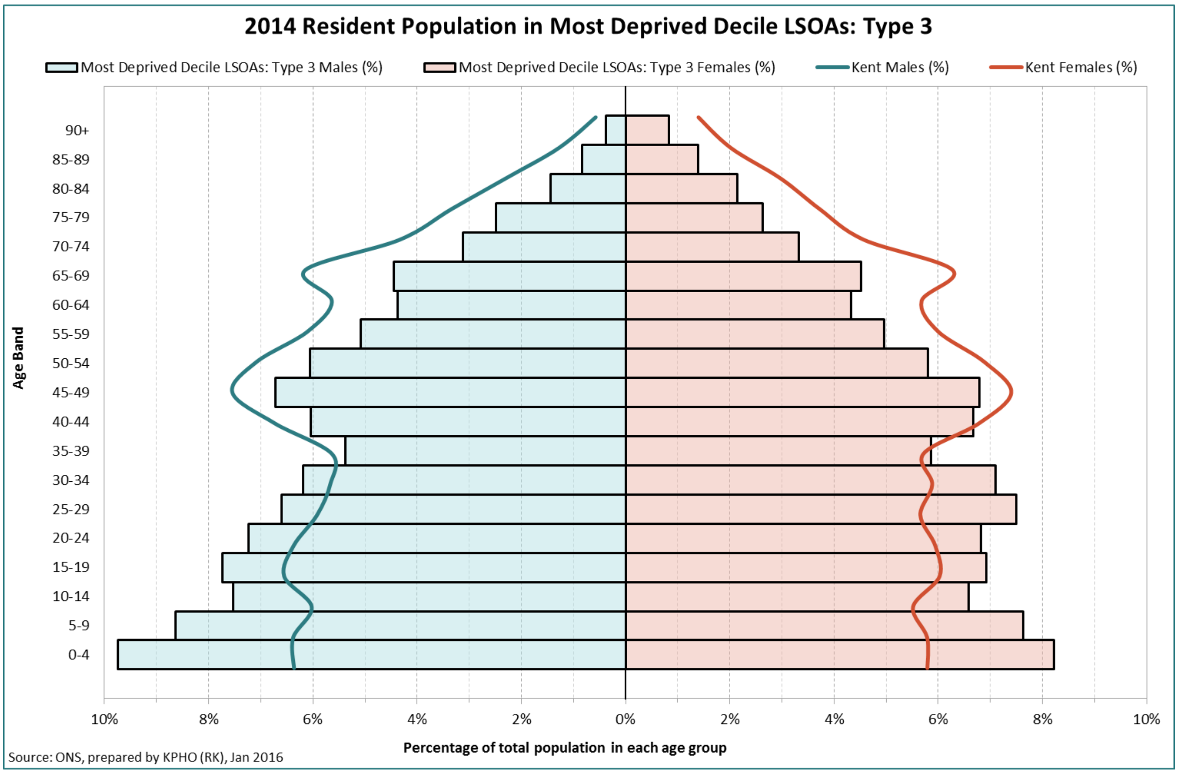
- Particularly high rates of disability ('activities limited a lot')
- High premature mortality.

Please see Appendix B for analysis of type 2 deprived areas at CCG-level, including detailed local maps for individual LSOAs falling into this cluster.

5.4 Type 3: Families in social housing

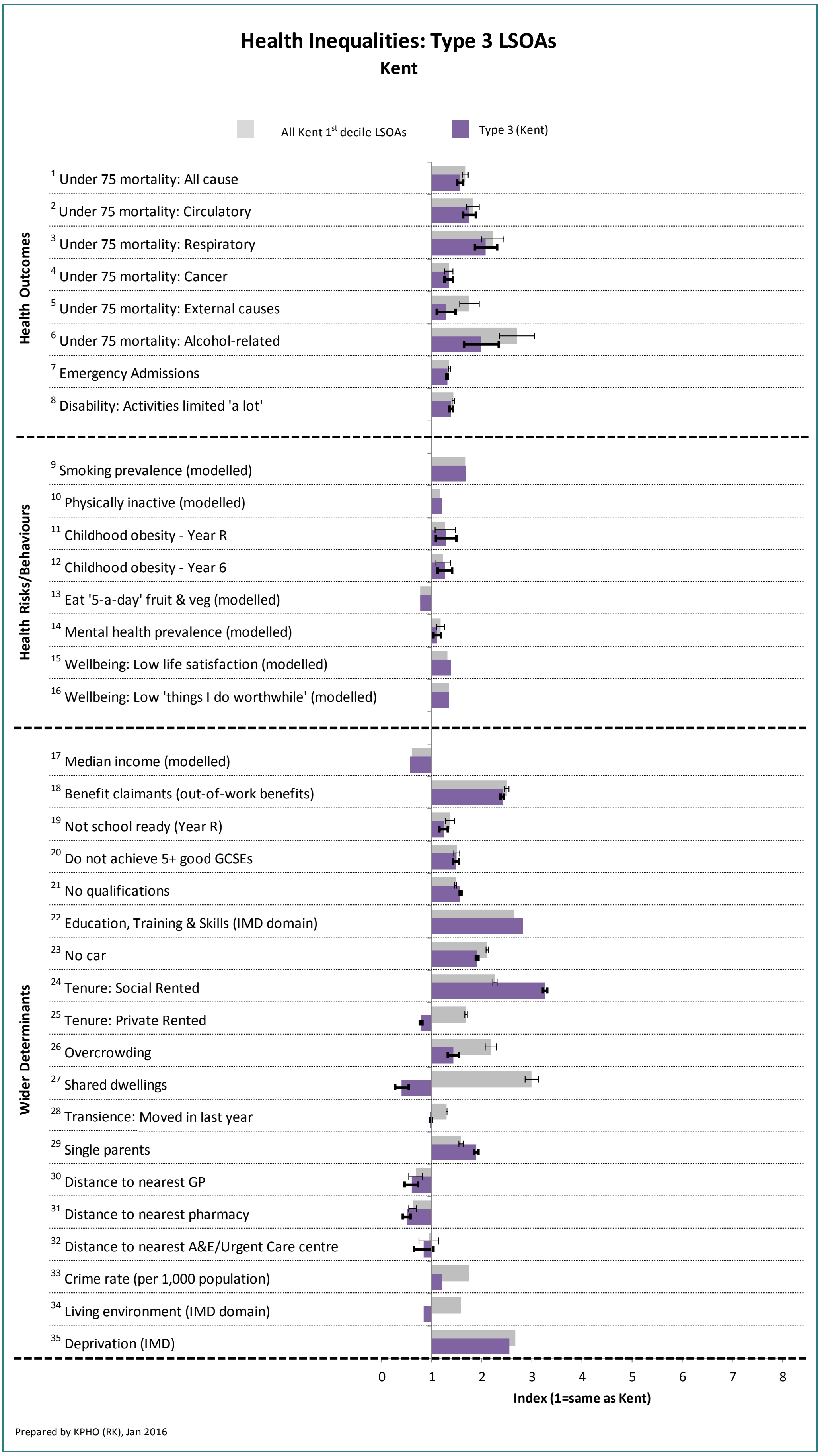
A total of 51 of the 88 most deprived decile LSOAs in Kent fall into type 3. This is the largest of the four deprivation types. These include LSOAs in Folkestone East, Aycliffe, Buckland Valley, St Radigans, Stanhope, Aylesford Green, Victoria, Davington Priory, Northgate, Gorrell, Seasalter, Wincheap, Swanley St Mary's, Dartford, Swanscombe, Kings Farm, Westcourt, Sheerness, Queenborough, Rushenden, Sittingbourne, Dane Valley, Garlinge, Newington, Parkwood, Shepway and Postley Road. For detailed local maps of the individual LSOAs falling into this cluster see the CCG-level summaries in Appendix B.

The chart below shows the age structure of the population of type 3 deprived areas in comparison with Kent as a whole.



This analysis shows that type 3 deprived areas have very high numbers children and lower numbers of over 50s in comparison with the Kent population as a whole.

The chart overleaf provides a summary of the characteristics of type 3 deprived areas in terms of health outcomes, health risks and behaviours, and the wider determinants of health. In this analysis type 3 deprived areas have been indexed against the average for Kent for each individual characteristic. Also shown is data for the most deprived decile as a whole.


Health Inequalities: Type 3 LSOAs
Kent
All Kent 1st decile LSOAs
Type 3 (Kent)
Health Outcomes
1 Under 75 mortality: All cause
2 Under 75 mortality: Circulatory
3 Under 75 mortality: Respiratory
4 Under 75 mortality: Cancer
5 Under 75 mortality: External causes
6 Under 75 mortality: Alcohol-related
7 Emergency Admissions
8 Disability: Activities limited 'a lot'
Health Risks/Behaviours
9 Smoking prevalence (modelled)
10 Physically inactive (modelled)
11 Childhood obesity - Year R
12 Childhood obesity - Year 6
13 Eat '5-a-day' fruit & veg (modelled)
14 Mental health prevalence (modelled)
15 Wellbeing: Low life satisfaction (modelled)
16 Wellbeing: Low 'things I do worthwhile' (modelled)
Wider Determinants
17 Median income (modelled)
18 Benefit claimants (out-of-work benefits)
19 Not school ready (Year R)
20 Do not achieve 5+ good GCSEs
21 No qualifications
22 Education, Training & Skills (IMD domain)
23 No car
24 Tenure: Social Rented
25 Tenure: Private Rented
26 Overcrowding
27 Shared dwellings
28 Transience: Moved in last year
29 Single parents
30 Distance to nearest GP
31 Distance to nearest pharmacy
32 Distance to nearest A&E/Urgent Care centre
33 Crime rate (per 1,000 population)
34 Living environment (IMD domain)
35 Deprivation (IMD)
0
1
2
3
4
5
6
7
8
Index (1=same as Kent)
Prepared by KPHO (RK), Jan 2016

Type 3 deprived areas are characterised by families with children in social housing.

This analysis highlights the following key characteristics of type 3 deprived areas in respect of some of the wider determinants of health, and in comparison with Kent as a whole:

- Low incomes
- Poor scores for education
- High numbers of out-of-work benefits claimants
- Particularly high number of single parents
- Better living environment and lower crime rates than other deprived areas.

In terms of health risks and behaviours, type 3 deprived areas have:

- High smoking prevalence
- Low levels of wellbeing.

In terms of health outcomes, type 3 deprived areas have:

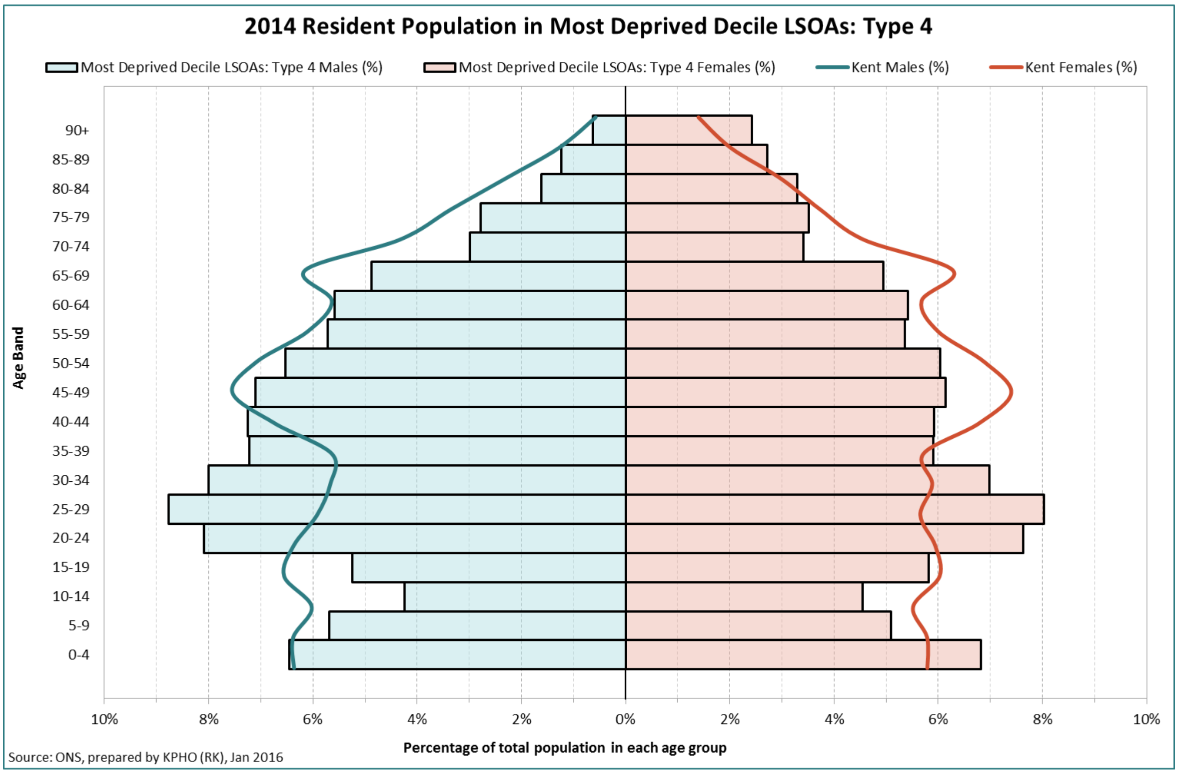
- High premature mortality rates
- High emergency hospital admission rates
- High rates of disability (‘activities limited a lot’).

Please see Appendix B for analysis of type 3 deprived areas at CCG-level, including detailed local maps for individual LSOAs falling into this cluster.

5.5 Type 4: Young people in poor quality accommodation

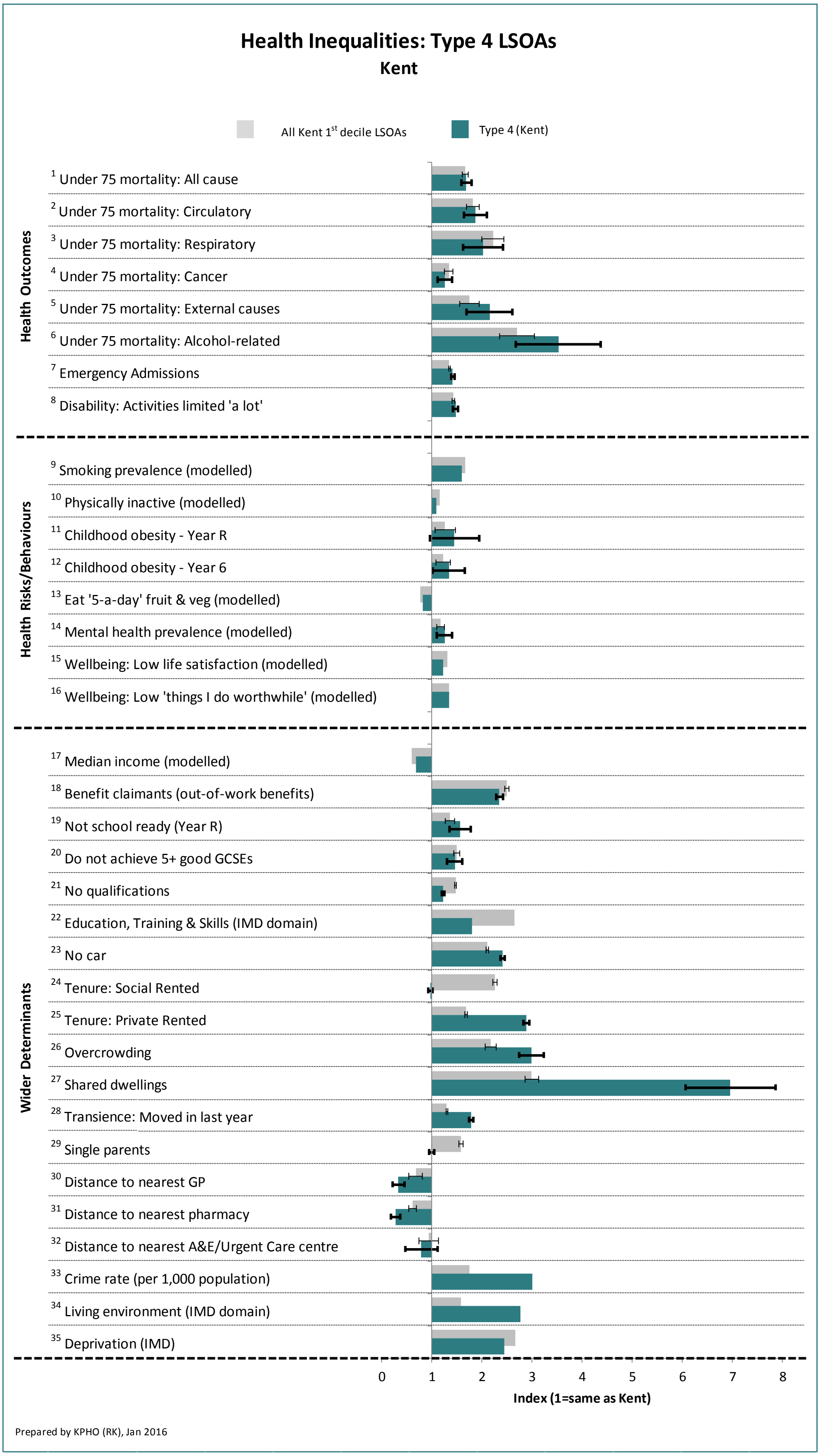
A total of 15 of the 88 most deprived decile LSOAs in Kent fall into type 4. These include LSOAs in Folkestone Harvey Central, Priory, Pencester, Heron, Herne Bay, Central Gravesend, Central Harbour (Ramsgate), Westbrook, Eastcliff and Cliftonville West. For detailed local maps of the individual LSOAs falling into this cluster see the CCG-level summaries in Appendix B.

The chart below shows the age structure of the population of type 4 deprived areas in comparison with Kent as a whole.



This analysis shows that type 4 deprived areas have high numbers of young adults and low numbers of school-age children and teenagers.

The chart overleaf provides a summary of the characteristics of type 4 deprived areas in terms of health outcomes, health risks and behaviours, and the wider determinants of health. In this analysis type 4 deprived areas have been indexed against the average for Kent for each individual characteristic. Also shown is data for the most deprived decile as a whole.


Health Inequalities: Type 4 LSOAs
Kent
All Kent 1st decile LSOAs
Type 4 (Kent)
Health Outcomes
1 Under 75 mortality: All cause
2 Under 75 mortality: Circulatory
3 Under 75 mortality: Respiratory
4 Under 75 mortality: Cancer
5 Under 75 mortality: External causes
6 Under 75 mortality: Alcohol-related
7 Emergency Admissions
8 Disability: Activities limited 'a lot'
Health Risks/Behaviours
9 Smoking prevalence (modelled)
10 Physically inactive (modelled)
11 Childhood obesity - Year R
12 Childhood obesity - Year 6
13 Eat '5-a-day' fruit & veg (modelled)
14 Mental health prevalence (modelled)
15 Wellbeing: Low life satisfaction (modelled)
16 Wellbeing: Low 'things I do worthwhile' (modelled)
Wider Determinants
17 Median income (modelled)
18 Benefit claimants (out-of-work benefits)
19 Not school ready (Year R)
20 Do not achieve 5+ good GCSEs
21 No qualifications
22 Education, Training & Skills (IMD domain)
23 No car
24 Tenure: Social Rented
25 Tenure: Private Rented
26 Overcrowding
27 Shared dwellings
28 Transience: Moved in last year
29 Single parents
30 Distance to nearest GP
31 Distance to nearest pharmacy
32 Distance to nearest A&E/Urgent Care centre
33 Crime rate (per 1,000 population)
34 Living environment (IMD domain)
35 Deprivation (IMD)
0 1 2 3 4 5 6 7 8
Index (1=same as Kent)
Prepared by KPHO (RK), Jan 2016

Type 4 deprived areas have a number of similar characteristics to type 1 deprived areas, including having high numbers of young adults in private rented accommodation.

This analysis highlights the following key characteristics of type 4 deprived areas in respect of some of the wider determinants of health, and in comparison with Kent as a whole:

- High levels of shared dwellings and overcrowding
- Better educated than the other deprivation types
- Particularly poor living environment with high crime rates
- Low incomes, but not as low as Type 1 areas
- High levels of out-of-work benefit claimants, but not as high has Type 1 areas
- Particularly high levels of movement/transiency.

In terms of health risks and behaviours, type 4 deprived areas have:

- High smoking prevalence.

In terms of health outcomes, type 4 deprived areas have:

- High premature mortality rates
- High emergency hospital admission rates
- High rates of disability (‘activities limited a lot’).

Please see Appendix B for analysis of type 4 deprived areas at CCG-level, including detailed local maps for individual LSOAs falling into this cluster.

Appendix A: Data sources

The charts in Section 5 summarising the characteristics of each deprivation type in terms of health outcomes, health risks and behaviours, and the wider determinants of health show data derived from the following sources:

1-6	Age-standardised mortality rates, 2006-2014. Source: PCMD. **2** ICD10: I00-I99. **3** ICD10: J00-J99. **4** ICD10: C00-C97. **5** ICD10: U00-Y99. **6** ICD10: F10, G31.2, G62.1, I42.6, K29.2, K70, K73, K74, K86.0, X45, X65, Y15.
7	Emergency admissions, 2012/13-2013/14. Source: SUS.
8	% self-reporting day-to-day activities 'limited a lot', 2011. Source: Census.
9	Modelled based on smoking prevalence data by Mosaic type. Source: Experian (TGI: 'Heavy', 'Medium' & 'Light' smokers combined).
10	Modelled based on % who do not exercise by Mosaic type. Source: Experian (TGI).
11-12	% children measured who were obese, 2013/14. Source: NCMP.
13	Modelled based on % who claim to eat '5-a-day' fruit and vegetables by Mosaic type. Source: Experian (TGI).
14	Modelled mental health prevalence based on GP practice-level data, 2014/15. Source: QOF.
15-16	Modelled wellbeing based on ONS Annual Population Survey (APS) data by Acorn type, 2011/12. Source: DCLG. **15** % scoring 0-6 for 'Overall, how satisfied are you with your life nowadays?' **16** % scoring 0-6 for 'Overall, to what extent do you feel the things you do in your life are worthwhile?'
17	Modelled based on median household income data by Mosaic type. Source: Experian (ConsumerView).
18	% claiming out of work benefits (defined as all those aged 16-64 who are jobseekers, claiming ESA & incapacity benefits, lone parents claiming Income Support and others on income related benefits), February 2015. Source: DWP (from Nomis).
19	% Year R pupils not achieving a good level of development, 2015. Source: KCC, MIU.

20 % pupils not achieving 5+ A*-C GCSEs (including English & Maths) at the end of Key Stage 4, 2015. Source: KCC, MIU.

21 % with no qualifications (based on persons aged 16+), 2011. Source: Census.

22 Education, Training & Skills IMD domain (average score), 2015. Source: DCLG.

23 % of households with no car or van, 2011. Source: Census.

24 % of households living in social rented accommodation, 2011. Source: Census.

25 % of households living in private rented accommodation, 2011. Source: Census.

26 % of households with an occupancy rating of -2 (i.e. with 2 too few rooms), 2011. Source: Census.

27 % of households with accommodation type 'shared dwellings', 2011. Source: Census.

28 % of households not living at the same address a year ago, 2011. Source: Census. Please note that OAs E00124937 & E00166800 have been removed from this analysis due to the undue influence of Eastchurch prison on levels of transience.

29 % of households with no adults or one adult and one or more children, 2011. Source: Census.

30-32 Distance to nearest GP/pharmacy/A&E or Urgent Care centre (in miles, as the crow flies from population weighted centroid of LSOA), 2015. Source: KCC Business Intelligence.

33 Crime rate (recorded crime per 1,000 population), Oct 2013 - Sept 2015. Source: data.police.uk.

34 Living Environment IMD domain (average score), 2015. Source: DCLG.

35 Index of Multiple Deprivation (IMD) (average score), 2015. Source: DCLG.

For some of the variables above, modelling techniques have been used to derive LSOA-level estimates for use in the analysis.

QOF Prevalence Modelling

Modelled estimates of recorded disease prevalence at LSOA-level have been produced using GP registration data extracted from HSCIC's maintained GP Payments system[12].

Disease prevalence estimates have been produced at LSOA-level by combining the numbers of people in each LSOA registered with each individual GP practice with that GP's disease prevalence rates (as recorded in the 2014/15 QOF). Thus, the model relies on the assumption that disease prevalence rates for the whole GP practice apply to the patients registered to that GP who live in the LSOA in question. This should be borne in mind when interpreting the results.

Mosaic Modelling

Experian's Mosaic classification system has been used to produce modelled estimates for smoking prevalence, physical inactivity, consumption of fruit and vegetables, and income.

Taking smoking as an example, prevalence estimates have been produced at LSOA-level by combining the Mosaic type-level population profile of each individual LSOA with smoking rates for each Mosaic type (as contained within the Mosaic Grand Index). Thus, the model relies on the assumption that smoking rates for a given Mosaic type, calculated by Experian at national level, apply to people of that Mosaic type within Kent.

[12] http://www.hscic.gov.uk/article/2021/Website-Search?productid=19077&q=Numbers+of+Patients+Registered+at+a+GP+Practice&sort=Relevance&size=10&page=1&area=both#top

Appendix B: CCG-level summaries

CCG-level summaries, including detailed local maps.

Ashford Profile.pdf
C&C Profile.pdf
DGS Profile.pdf
South Kent Coast Profile.pdf
Swale Profile.pdf
Thanet Profile.pdf
West Kent Profile.pdf

Appendix C: Deprivation types by LSOA

Data file detailing deprivation types by LSOA.

Appendix C.xlsx

Accessed at: https://www.ncbi.nlm.nih.gov/pubmed/20871180
https://www.ncbi.nlm.nih.gov/pubmed/20871180

Noise Health. 2010 Oct-Dec;12(49):255-62. doi: 10.4103/1463-1741.70504.

Night time aircraft noise exposure and children's cognitive performance.

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1
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Abstract

Chronic aircraft noise exposure in children is associated with impairment of reading and long-term memory. Most studies have not differentiated between day or nighttime noise exposure. It has been hypothesized that sleep disturbance might mediate the association of aircraft noise exposure and cognitive impairment in children. This study involves secondary analysis of data from the Munich Study and the UK Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) Study sample to test this. In the Munich study, 330 children were assessed on cognitive measures in three measurement waves a year apart, before and after the switchover of airports. Self-reports of sleep quality were analyzed across airports, aircraft noise exposure and measurement wave to test whether changes in nighttime noise exposure had any effect on reported sleep quality, and whether this showed the same pattern as for changes in cognitive performance. For the UK sample of the RANCH study, night noise contour information was linked to the children's home and related to sleep disturbance and cognitive performance. In the Munich study, analysis of sleep quality questions showed no consistent interactions between airport, noise, and measurement wave, suggesting that poor sleep quality does not mediate the association between noise exposure and cognition. Daytime and nighttime aircraft noise exposure was highly correlated in the RANCH study. Although night noise exposure was significantly associated with impaired reading and recognition memory, once home night noise exposure was centered on daytime school noise exposure, night noise had no additional effect to daytime noise exposure. These analyses took advantage of secondary data available from two studies of aircraft noise and cognition. They were not initially designed to examine sleep disturbance and cognition, and thus, there are methodological limitations which make it less than ideal in giving definitive answers to these questions. In conclusion, results from both studies suggest that night aircraft noise exposure does not appear to add any cognitive performance decrement to the cognitive decrement induced by daytime aircraft noise alone. We suggest that

the school should be the main focus of attention for protection of children against the effects of aircraft noise on school performance.

PMID:

20871180

DOI:

10.4103/1463-1741.70504

[Indexed for MEDLINE]

Free full text

TOTAL

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St Nicholas Roundabout Monitor No. 1	Departures	13/01/2004 21:32:00	28	AN26
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Clarendon House Grammar School Monitor No. 2	Departures	15/01/2004 11:31:00	28	DC86
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St Nicholas Roundabout Monitor No. 1	Departures	16/01/2004 15:27:00	28	DC86
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Clarendon House Grammar School Monitor No. 2	Departures	16/01/2004 21:32:00	28	B742
Clarendon House Grammar School Monitor No. 2	Departures	17/01/2004 17:22:00	28	B742
Clarendon House Grammar School Monitor No. 2	Departures	17/01/2004 17:22:00	28	B742
Clarendon House Grammar School Monitor No. 2	Departures	17/01/2004 20:45:00	10	B742
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St Nicholas Roundabout Monitor No. 1	Departures	18/01/2004 20:45:00	28	A124
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St Nicholas Roundabout Monitor No. 1	Departures	20/01/2004 00:49:00	28	AN22
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Clarendon House Grammar School Monitor No. 2	Departures	20/01/2004 18:52:00	28	B742
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Clarendon House Grammar School Monitor No. 2	Departures	20/01/2004 20:34:00	10	B742
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Clarendon House Grammar School Monitor No. 2	Departures	21/01/2004 00:02:00	28	B742
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St Nicholas Roundabout Monitor No. 1	Departures	21/01/2004 20:58:00	28	DC86
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Clarendon House Grammar School Monitor No. 2	Departures	23/01/2004 15:51:00	10	B742
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St Nicholas Roundabout Monitor No. 1	Departures	23/01/2004 21:07:00	28	DC86
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Clarendon House Grammar School Monitor No. 2	Departures	24/01/2004 00:41:00	28	B742
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St Nicholas Roundabout Monitor No. 1	Departures	16/03/2005 20:56:00	28	DC86
St Nicholas Roundabout Monitor No. 1	Departures	16/03/2005 21:29:00	28	DC86
Clarendon House Grammar School Monitor No. 2	Arrivals	17/03/2005 07:45:00	28	VC10
St Nicholas Roundabout Monitor No. 1	Departures	17/03/2005 09:31:00	28	VC10
Clarendon House Grammar School Monitor No. 2	Arrivals	18/03/2005 07:37:00	28	VC10
St Nicholas Roundabout Monitor No. 1	Departures	18/03/2005 09:07:00	28	VC10
St Nicholas Roundabout Monitor No. 1	Departures	28/03/2005 00:35:00	28	DC86
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St Nicholas Roundabout Monitor No. 1	Departures	18/04/2005 19:57:00	28	AN12
Clarendon House Grammar School Monitor No. 2	Departures	27/04/2005 21:46:00	10	DC86

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St Nicholas Roundabout Monitor No. 1	Departures	09/05/2005 08:05:00	28	DC86
St Nicholas Roundabout Monitor No. 1	Arrivals	13/05/2005 13:06:00	10	IL76
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St Nicholas Roundabout Monitor No. 1	Departures	22/05/2005 17:53:00	28	DC86
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Unknown	Arrivals	18/03/2008 11:23:00	28	B742
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97.4	89.3
98.5	92.3
100.8	96.1
100.9	95.1
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98.5	92.2
98.2	92.2
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87.7	77.3
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87.8	76.2
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89.2	76.5
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89.5	79.4
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86.6	76.4
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88.3	75.2
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89.0	77.3
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85.4	75.6
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88.9	79.8
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99.3	93
99.9	93.4
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100.9	93.9

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88.2		78.6
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86.2		75
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101.6		94.8
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90.4		81.1
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99.3		88.2
92.7		83.1
95.2		84.9
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100.7		94.2
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95.8		85.1
101.8		96.2

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94.5	84.9
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99.0	92.1
99.2	89.6
97.0	91
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96.0	82.4
100.0	94.2
93.6	82.9
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100.3	90.8
100.0	93.7
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94.0	83.4
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108.0	101.8
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105.0	97.6
97.7	88.3
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101.5	92.8
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99.6	93.3
104.2	97.8
104.8	96.2
102.1	93.7
101.2	90.4
97.5	86.5
92.5	84.9
108.2	102.1

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99.7	93.4
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96.5	85.6
96.0	85
108.7	101.8
104.4	98
94.9	83.3
109.1	100.2
103.9	97.4
105.0	96
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100.5	93.8
90.9	82.8
95.5	90.9
103.4	95.4
99.4	91.8
97.7	91.8
100.0	93.4
98.3	91
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102.9	96.3
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99.7	91.1
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99.0	92.4
98.9	91.9
99.0	91.5
98.6	91.9
98.1	92.2
99.1	91.1
105.8	106.5

Aircraft noise effects on health

Prepared for the Airports Commission

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Table of Contents

1. Introduction

Recent years have seen an increase in the strength of the evidence linking environmental noise exposure (road, rail, airport and industrial noise) to health. The World Health Organization (WHO, 2011) recently estimated that between 1 and 1.6 million healthy life years (Disability-Adjusted Life Years) are lost annually because of environmental noise exposure[1], such as road traffic noise and aircraft noise, in high income western European Countries. The WHO estimated that each year 903,000 DALYS are lost due to sleep disturbance; 654,000 DALYS due to noise annoyance; 61,000 DALYS due to heart disease; and 45,000 DALYS due to cognitive impairment in children.

Aircraft noise negatively influences health if the exposure is long-term and exceeds certain levels (Basner et al., 2014). This review briefly summarizes the strength of the evidence for aircraft noise effects on cardiovascular health, sleep disturbance, annoyance, psychological well-being, and effects on children's cognition and learning, as well as briefly discussing guidelines for environment noise exposure. This evidence is related to the three shortlisted schemes for the new runway.

This is a selective review focusing on reviews assessing the strength of the evidence, as well as high quality, robust, large-scale epidemiological field studies of aircraft noise exposure, highlighting studies that have been conducted within the United Kingdom, where possible. It represents key studies within the field but should not be considered an exhaustive review. Studies of road traffic noise, as opposed to aircraft noise, have only been included where evidence for aircraft noise exposure is unavailable.

2. Aircraft noise effects on health: a review of recent evidence

2.1. Cardiovascular health

Over the past 10 years, evidence that aircraft noise exposure leads to increased risk for poorer cardiovascular health has increased considerably. A recent review, suggested that risk for cardiovascular outcomes such as high blood pressure (hypertension), heart attack, and stroke, increases by 7 to 17% for a 10dB increase in aircraft or road traffic noise exposure (Basner et al., 2014). A review of the evidence for children concluded that there were associations between aircraft noise and high blood pressure (Paunović et al., 2011), which may have implications for adult health (Stansfeld & Clark, 2015).

The HYENA study (HYpertension and Exposure to Noise near Airports) examined noise effects on the blood pressure (hypertension) of 4,861 people, aged 45-70 years, who had lived for over 5 years near 7 major European airports including London Heathrow; Amsterdam Schiphol; Stockholm Arlanda & Bromma; Berlin Tegel, Milan Malpensa; and Athens Eleftherios Venizelos (Jarup et al., 2008). High blood pressure was

[1] The range 1 to 1.6 million is given as it is not known if the effects for the different health outcomes are additive or if they might interact/co-occur.

assessed via measurements and medication use. The HYENA study found that a 10dB increase in aircraft noise at night (L_{night}) was associated with a 14% increase in odds for high blood pressure but day-time aircraft noise ($L_{Aeq\ 16\ hour}$) did not increase the odds for high blood pressure (Jarup et al., 2008). The HYENA study did not find an association between day-time aircraft noise and high blood pressure which might be because many residents work away from home during the day-time, leading to potential mis-classification of their day-time aircraft noise exposure. The HYENA study also found that a 10dB increase in night-time aircraft noise was associated with a 34% increase in the use of medication for high blood pressure in the UK (Floud et al., 2011). The HYENA study is a high quality large-scale study of aircraft noise exposure effects on blood pressure, which includes a population sample around London Heathrow airport. One short-coming of the study is that it assesses noise and health at the same point in time, meaning that we cannot be sure whether noise exposure occurred before the poorer health outcomes, or whether the poorer health outcomes may have preceded the noise exposure.

A recent study around London Heathrow airport examined risks for hospital admission and mortality for stroke, coronary heart disease and cardiovascular disease for around 3.6 million people living near London Heathrow airport (Hansell et al., 2013). Both day-time ($L_{Aeq\ 16\ hour}$) and night-time (L_{night}) aircraft noise exposure were related to increased risk for a cardiovascular hospital admission. Compared to those exposed to aircraft noise levels below 51dB in the day-time, those exposed to aircraft noise levels over 63dB in the day-time had a 24% higher chance of a hospital admission for stroke; a 21% higher chance of a hospital admission for coronary heart disease; and a 14% higher chance of a hospital admission for cardiovascular disease. These estimates took into account age, sex, ethnicity, deprivation and lung cancer mortality as a proxy for smoking. These results were also not accounted for by air pollution, which was adjusted for in the analyses. Similar effects were also found between aircraft noise exposure and mortality for stroke, coronary heart disease, and cardiovascular disease. The study concluded that high levels of aircraft noise were associated with increased risks of stroke, coronary heart disease, and cardiovascular disease for both hospital admissions and mortality in areas near Heathrow airport.

Further longitudinal evidence for an association between aircraft noise exposure and mortality from heart attacks comes from a large-scale Swiss study of 4.6 million residents over 30 years of age (Huss et al., 2010). This study found that mortality from heart attacks increased with increasing level and duration of aircraft noise exposure (over 15 years), but there were no associations between aircraft noise exposure and other cardiovascular outcomes including stroke or circulatory disease. The lack of association between aircraft noise and stroke differs from the findings of the similar study conducted around Heathrow airport, which did find an association of aircraft noise on stroke mortality (Hansell et al., 2013).

It is not uncommon for studies in this field to demonstrate some inconsistencies in the specific cardiovascular outcomes for which significant effects of aircraft noise associations are found. There are several explanations for this. Firstly, demonstrating environmental noise effects on cardiovascular disease requires very large samples.

Even in large samples effects may not be statistically significant, as the confidence intervals for the estimate of the effect can be wide, if the cardiovascular outcome does not have a high prevalence, e.g. incidence of stroke. Thus, studies vary in their sample size and in their ability to examine a range of cardiovascular outcomes. Secondly, with epidemiological studies, there is always the potential for residual confounding: the analyses may still not be taking into account all factors, which might be influencing the association between aircraft noise and cardiovascular disease. Thirdly, there is always the possibility of exposure mis-classification: the estimated aircraft noise exposure may be incorrect for some of the sample, which could influence the findings. For example, there is a limitation to using day-time aircraft noise exposure at home for adult samples, when they may work away from their home environment. Fourthly, there is variation in the level and range of aircraft noise exposures examined, which could explain differences between the studies. Despite these differences between the aircraft noise studies, the most recent meta-analysis of the field (Babisch, 2014) concluded that aircraft noise exposure was associated with increased risk for cardiovascular outcomes such as high blood pressure, heart attack and stroke.

It is biologically plausible that long-term exposure to environmental noise might influence cardiovascular health (Babisch, 2014). Figure 2.1. shows a model of proposed pathways between environmental noise exposure and cardiovascular diseases (Babisch, 2014). In brief, increased stress associated with noise exposure might cause physiological stress reactions in an individual, which in turn can lead to increases in established cardiovascular disease risk factors such as blood pressure, blood glucose concentrations, and blood lipids (blood fats). These risk factors lead to increased risk of high blood pressure (hypertension) and arteriosclerosis (e.g. narrowing of arteries due to fat deposits) and are related to serious events such as heart attacks and strokes (Babisch, 2014; Basner et al., 2014). The stress that triggers this pathway can operate directly via sleep disturbance or indirectly via interference with activities and annoyance.

To date, few studies have examined whether aircraft noise exposure influences metabolic risk factors for cardiovascular health, such as Type II diabetes, body mass index, and waist circumference. Such factors would lie on the proposed pathway between aircraft noise exposure and cardiovascular diseases. A recent study of long-term exposure to aircraft noise in Sweden found that exposure was associated with a larger waist circumference but less clearly with Type II diabetes and body mass index (Eriksson et al., 2014). This is an area of research where further evidence should be forthcoming in the next few years.

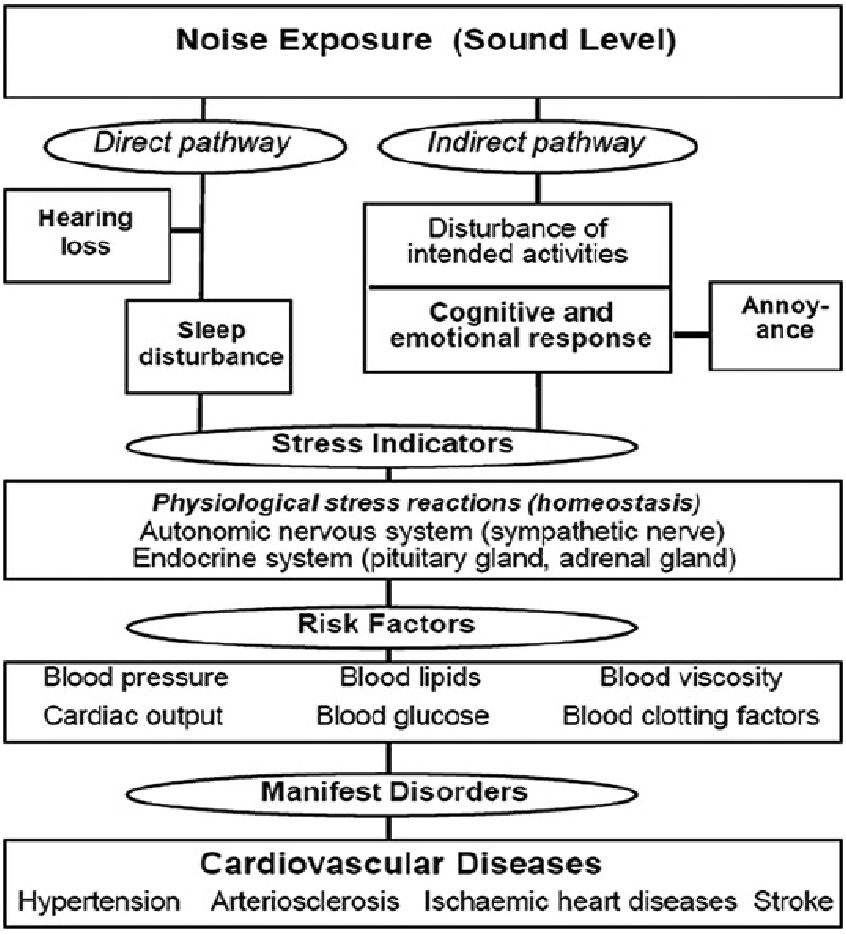

Figure 2.1. Pathways from environmental noise exposure to cardiovascular disease (Babisch, 2014).

2.2. Sleep disturbance

The WHO estimated sleep disturbance to be the most adverse non-auditory effect of environmental noise exposure (Basner et al., 2014; WHO, 2011). Undisturbed sleep of a sufficient number of hours is needed for alertness and performance during the day, for quality of life, and for health (Basner et al., 2014). Humans exposed to sound whilst asleep still have physiological reactions to the noise which do not adapt over time including changes in breathing, body movements, heart rate, as well as awakenings (Basner et al., 2014). The elderly, shift-workers, children and those with poor health are thought to be at risk for sleep disturbance by noise (Muzet, 2007).

The effect of night-time aircraft noise exposure has been explored for a range of sleep outcomes ranging from subjective self-reported sleep disturbance and perceived sleep quality, to more objective measures of interference with ability to fall asleep, shortened sleep duration, awakenings, and increased bodily movements as assessed by polysomnography[2] (Michaud et al., 2007). Most evidence comes from studies of self-reported sleep disturbance. However, self-reported sleep disturbance outcomes are vulnerable to bias, as such measures are likely to be influenced by noise annoyance and other demographic factors (Clark & Stansfeld, 2011).

Reviews have concluded that there is evidence for an effect of night-time aircraft noise exposure on sleep disturbance from community based studies (Hume et al., 2012; Miedema & Vos, 2007). However, some reviews have concluded that the evidence is contradictory and inconclusive (Jones, 2009; Michaud et al., 2007), which might be explained by methodological differences between studies of noise effects on sleep disturbance. A meta-analysis of 24 studies, including nearly 23,000 individuals exposed to night-time noise levels ranging from 45-65dBA, found that aircraft noise was associated with greater self-reported sleep disturbance than road traffic noise (Miedema & Vos, 2007). However, another study, whilst confirming that aircraft noise was associated with greater self-reported sleep disturbance than road traffic noise, found that when polysomnography measures of sleep disturbance were analysed that road traffic noise was associated with greater disturbance than aircraft noise (Basner et al., 2011).

Polysomnography enables the assessment of noise effects on different stages of the sleep cycle. The average sleep cycle last between 90 to 110 minutes, and an individual experiences between four to six sleep cycles per night (Michaud et al., 2007). Figure 2.2. describes the duration and characteristics of each stage of the sleep cycle (Clark & Stansfeld, 2011) from wake, through non-rapid eye movement (NREM) stages 1 to 4, and rapid eye movement (REM) sleep. It is usual for people to move between NREM sleep stages several times before undergoing REM sleep. Slow-wave sleep (NREM stage 3 and 4) occurs more frequently in the first half of the night, and REM sleep propensity is greater in the second half of the night. Sleep disturbance is indicated by less stage 3, stage 4 and REM sleep, and by more wake and stage 1 sleep, as well as more frequent changes in sleep stage (Basner & Siebert, 2010).

There is evidence that aircraft noise influences the time spent in different sleep stages, with aircraft noise reducing slow-wave sleep (NREM Stage 4) and REM sleep and increasing NREM Stages 1, 2 & 3 (Basner et al., 2008; Swift, 2010). This evidence, taken with the increase in REM sleep in the later stages of the night might have implications for early morning (04.00-06.30 hours) flight operations at airports.

A laboratory study compared the potential effects of changes in the night-time curfew at Frankfurt airport on sleep disruption (Basner & Siebert, 2010), using polysomnography on 128 subjects over 13 nights. Three different operational scenarios were compared: scenario 1 was based on 2005 air traffic at Frankfurt airport which included night flights; scenario 2 was as scenario 1 but cancelled flights between 23.00-05.00 hours; scenario 3 was as scenario 1 but with flights between 23.00-05.00

[2] Polysomnography records biophysiological changes that occur during sleep, including brain waves using electroencephalography (EEG), eye movements using electroculography (EOG), muscle activity using electromyography (EMG), and heart rhythm using electrocardiography (ECG).

hours rescheduled to the day-time and evening periods. The study found that compared to the night without a curfew on night flights (scenario 1), small improvements were observed in sleep structure for the nights with curfew, even when the flights were rescheduled to periods before and after the curfew period. However, the change in the amount of time spent in the different sleep stages for the different scenarios was small, which might be explained by the small number of night-flights (on average 4 take-offs per hour) in the Frankfurt airport scenarios examined: larger effects may be observed for airports with a greater number of night-flights. The authors concluded that the benefits for sleep seen in the scenario involving rescheduling of flights rather than cancellation may be offset by the expected increase in air traffic during the late evening and early morning hours for those who go to bed before 22.30 or after 01.00 hours.

Wake	
Non-rapid eye movement (NREM)	
Stage 1	Light stage of sleep Lasts 5-10 minutes Bridge between wakefulness and sleep
Stage 2	Light stage of sleep Lasts around 20 minutes Brain waves of increased frequency Increased heart rate variability
Stage 3	Transition to deeper stages of sleep Increased amount of delta waves of lower frequency
Stage 4	Deepest stage of sleep Characterised by a greater number of delta waves
Rapid Eye Movement (REM) sleep	Typically starts 70-90 minutes after falling asleep Characterised by rapid eye movements Increases in brain activity Greater variability in respiration rate, blood pressure and heart rate

Figure 2.2. Stages of sleep, adapted from (Clark & Stansfeld, 2011).

The WHO Europe Night Noise Guidelines (WHO, 2009) were based on expert-consensus that there was sufficient evidence that nocturnal environmental noise exposure was related to self-reported sleep disturbance and medication use, and that there was some evidence for effects of nocturnal noise exposure on high blood pressure (hypertension) and heart attacks. The WHO Europe Night Noise Guidelines state that the target for nocturnal noise exposure should be 40 dB $L_{night,\ outside}$, which should protect the public as well as vulnerable groups such as the elderly, children, and the chronically ill from the effects of nocturnal noise exposure on health. The Night Noise Guidelines also recommend the level of 55 dB $L_{night,\ outside}$, as an interim target for countries wishing to adopt a step-wise approach to the guidelines. It is worth noting that the 40dB $L_{night\ outside}$ guideline represents a very low level of noise exposure, e.g. a refrigerator humming.

There have been fewer studies on aircraft noise exposure and sleep in children (Stansfeld & Clark, 2015), even though children are a group thought to be vulnerable to the effects of sleep disturbance (Pirrera et al., 2010). Drawing on studies of road traffic noise exposure in children, studies have suggested associations with sleeping problems (Tiesler et al., 2013), sleep quality (Ohrstrom et al., 2006) and sleepiness during the day (Ohrstrom et al., 2006) but not with difficulties falling asleep (Ohrstrom et al., 2006). However, these studies are limited by small samples and self-reports of sleep. Children sleep outside the typical hours used to denote night-time noise exposure around airports (e.g. L_{night} is typically 23.00 hours to 07.00 hours), so exposures during the hours of the evening and morning, which would fall within day-time exposure metrics may also be relevant when considering sleep disturbance effects for children.

2.3. Annoyance

Annoyance is the most prevalent community response in a population exposed to environmental noise. The term annoyance is used to describe negative reactions to noise such as disturbance, irritation, dissatisfaction and nuisance (Guski, 1999). Annoyance can also be accompanied by stress-related symptoms, leading to changes in heart rate and blood pressure, as described above. Acoustic factors, such as the noise source and sound level, account for only a small to moderate amount of annoyance responses: other factors such as the fear associated with the noise source, interference with activities, ability to cope, noise sensitivity, expectations, anger, attitudes to the source – both positive or negative, and beliefs about whether noise could be reduced by those responsible influence annoyance responses (WHO, 2000).

Annoyance scales are commonly used within European policy to measure the quality of life impact of environmental noise exposure on communities around airports. An International Standard is in place governing the measurement of annoyance in community surveys (Fields et al., 2001; ISO/TS, 2003), with questions typically taking the format “Thinking about the last year when you are at home, how much does the noise from aircraft bother, disturb or annoy you?” with responses ideally given on a 10 point scale with 0 being ‘not at all annoyed’ and 10 being “extremely annoyed”. This question is often reported as the % of the population “highly annoyed” or “annoyed”, where “highly annoyed” is 72% or more on the scale and “annoyed” is 50% or more on the scale.

Exposure to aircraft noise at 60dB L_{den} is estimated to be associated with 38% of the population reporting being “annoyed” and 17% being “highly annoyed” (EC, 2002). Exposure to aircraft noise at 65dB L_{den} is estimated to be associated with 48% of the population reporting being “annoyed” and 26% being “highly annoyed” (EC, 2002). However, in recent years, several studies have suggested that aircraft noise annoyance around major airports in Europe has increased (Babisch et al., 2009; Janssen et al., 2011; Schreckenberg et al., 2010), so the percentage of the population reporting being “annoyed” or “highly annoyed” at each noise exposure level may have increased since these figures were put forward by the European Commission in 2002 (EC, 2002).

Annoyance responses can also increase in relation to a change in airport operations. A study around Zurich airport found that residents who experienced a significant increase in aircraft noise exposure due to an increase in early morning and late evening flight operations had a pronounced over-reaction of annoyance i.e. the annoyance reaction was greater than that which would be predicted by the level of noise exposure (Brink et al., 2008).

Children also report annoyance responses, although it is not known at what age children being to exhibit annoyance responses. The RANCH (Road traffic and Aircraft Noise exposure and children's Cognition and Health) study found that children aged 9-11 years of age living near London Heathrow, Amsterdam Schiphol, and Madrid Barajas airports, reported annoyance for aircraft noise exposure at school and at home (van Kempen et al., 2009). For school exposure the percentage of "highly annoyed" children increased from about 5.1% at 50dB $L_{Aeq\ 16\ hour}$, to 12.1% at 60dB $L_{Aeq\ 16\ hour}$.

2.4. Psychological health

Following on from annoyance, it has been suggested that long-term noise exposure might influence psychological health. However, overall the evidence for aircraft noise exposure being linked to poorer well-being, lower quality of life, and psychological ill-health is not as strong or consistent as for other health outcomes, such as cardiovascular disease. A recent study of 2300 residents near Frankfurt airport found that annoyance but not aircraft noise levels per se ($L_{Aeq16\ hour}$, L_{night}, L_{den}) was associated with self-reported lower quality of life (Schreckenberg et al., 2010).

Several studies of children around London Heathrow airport have shown no effect of aircraft noise at school on children's psychological health or cortisol levels (Haines et al., 2001a; Haines et al., 2001b; Stansfeld et al., 2009): we would expect cortisol levels to be raised in children with depression. However, there may be a small effect of aircraft noise on hyperactivity symptoms. The West London Schools Study of 451 children around Heathrow airport, aged 8-11 years found higher rates of hyperactivity symptoms for children attending schools exposed to aircraft noise exposure >63dB $L_{Aeq\ 16\ hour}$ compared with <57dB $L_{Aeq\ 16\ hour}$ (Haines et al., 2001a). A similar effect was observed in the RANCH study where 10dB $L_{Aeq\ 16\ hour}$ increase in aircraft noise exposure at school was associated with 0.13 increase in hyperactivity symptoms (Stansfeld et al., 2009). However, these increases in hyperactivity symptoms, whilst statistically significant, are extremely small and most likely not of clinical relevance. Aircraft noise exposure does not appear to be causing children to develop hyperactivity problems.

There have been fewer studies of aircraft noise effects on adult psychological health. The HYENA study, found that a 10dB increase in day-time ($L_{Aeq\ 16\ hour}$) was associated with a 28% increase in anxiety medication use: similarly, a 10dB increase in night-time (L_{night}) aircraft noise was associated with a 27% increase in anxiety medication use. However, day-time and night-time aircraft noise exposure were not associated with sleep medication or anti-depressant medication use (Floud et al., 2011). Anxiety medication is prescribed for individuals experiencing levels of anxiety and worry that interfere with their ability to function effectively: they can also be prescribed for sleeping problems. A sub-study of the HYENA study found that salivary cortisol (a stress hormone which is higher in people with depression) was 34% higher for women exposed to aircraft noise > 60dB $L_{Aeq\ 24\ hour}$, compared to women exposed to less than 50dB $L_{Aeq\ 24\ hour}$ (Selander et al., 2009). However, no association between aircraft noise and salivary cortisol was found for men.

2.5. Implications of the evidence for aircraft noise effects on health for the shortlisted options for a new runway

2.5.1. Populations exposed for each shortlisted option

This section considers the implications of the current evidence for aircraft noise effects on cardiovascular health, sleep disturbance, annoyance, and psychological health for the three shortlisted options for a new runway:

- Gatwick 2-R promoted by Gatwick Airport Limited (GAL).
- Heathrow-NWR promoted by Heathrow Airport Limited (HAL).
- Heathrow-ENR promoted by Heathrow Hub (HH).

Information relating to each of these options is taken from the "Noise: Baseline", the "Noise: Local Assessment" and the "Noise: Local Assessment Addendum" reports prepared by Jacobs for the Airport Commission (all available on https://www.gov.uk/government/organisations/airports-commission).

The Commission has evaluated these shortlisted options in terms of populations exposed to several noise metrics including $L_{Aeq\ 16\ hour}$, $L_{Aeq\ 8\ hour}$, L_{den}, N70 & N60. Most of the evidence for aircraft noise effects on health has made use of average noise metrics such as $L_{Aeq\ 16\ hour}$ and $L_{Aeq\ 8\ hour.}$ This section relates key messages from the evidence to the estimated populations exposed to $L_{Aeq\ 16\ hour}$ and $L_{Aeq\ 8\ hour}$ for each of the shortlisted options using the predefined exposure categories used by the Commission of >54, >57, >60, >63, >66, >69, and >72dB for $L_{Aeq\ 16\ hour}$ and >48, >51, >54, >57, >60, >63, >66, >69, and >72dB for $L_{Aeq\ 8\ hour}$.

The magnitude of the populations exposed to aircraft noise varies between the shortlisted options for each scheme and is nearly always greater in terms of the net population exposed in the Do-Something scenario compared with the Do-Minimum scenario.

2.5.1.1. Gatwick 2-R

For Gatwick-2-R, the estimated population exposed to day-time noise levels greater than 54dB $L_{Aeq\ 16\ hour}$ is 17,600 in 2030, 19,400 in 2040, and 24,600 in 2050. The estimated population exposed to night-time noise levels greater than 48dB $L_{Aeq\ 8\ hour}$ is 22,300 in 2030, 17,400 in 2040 and 18,600 in 2050.

Table 2.1. Estimated population exposed to levels greater than 54dB $L_{Aeq\ 16\ hour}$ and $L_{Aeq\ 8\ hour}$ in 2030, 2040, & 2050 for Gatwick 2-R.

	Gatwick 2-R		
	2030	**2040**	**2050**
Day-time			
54dB $L_{Aeq\ 16\ hour}$	17,600	19,400	24,600
57dB $L_{Aeq\ 16\ hour}$	4,900	5,300	7,200
60dB $L_{Aeq\ 16\ hour}$	1,700	1,900	2,800
63dB $L_{Aeq\ 16\ hour}$	400	500	800
66dB $L_{Aeq\ 16\ hour}$	<50	<50	200
69dB $L_{Aeq\ 16\ hour}$	<50	<50	<50
72dB $L_{Aeq\ 16\ hour}$	<50	<50	<50
Night-time			
48dB $L_{Aeq\ 8\ hour}$	22,300	17,400	18,600
51dB $L_{Aeq\ 8\ hour}$	6,500	5,200	5,400
54 dB $L_{Aeq\ 8\ hour}$	2,900	2,300	2,400
57dB $L_{Aeq\ 8\ hour}$	800	500	700
60dB $L_{Aeq\ 8\ hour}$	200	100	100
63dB $L_{Aeq\ 8\ hour}$	<50	<50	<50
66dB $L_{Aeq\ 8\ hour}$	<50	<50	<50
69dB $L_{Aeq\ 8\ hour}$	<50	<50	<50
72dB $L_{Aeq\ 8\ hour}$	<50	<50	<50

These estimates for the population exposed in the Do-Something scenario for Gatwick 2-R are higher than the estimates for the Do-Minimum scenario in 2030, 2040 and 2050. The differences in the 2030, 2040, and 2050 Do-Something scenario compared with the 2030, 2040, and 2050 Do-Minimum scenario are summarized below for day-time and night-time exposure:

2030 $L_{Aeq\ 16\ hour}$
- >54 dB: An increase of 9,600 (from 8,000 to 17,600)
- >57 dB: An increase of 2,700 (from 2,200 to 4,900)
- >60 dB: An increase of 600 (from 1,100 to 1,700)
- >63 dB: No discernible difference from (from 400 to 400)
- >66 dB: A reduction from 300 to <50
- >69 dB: A reduction from 200 to <50
- >72 dB: No discernible difference (from <50 to <50)

2040 $L_{Aeq\ 16\ hour}$
• >54 dB: An increase of 12,000 (from 7,400 to 19,400)
• >57 dB: An increase of 3,100 (from 2,200 to 5,300)
• >60 dB: An increase of 1,000 (from 900 to 1,900)
• >63 dB: No discernible difference (from 500 to 500)
• >66 dB: A reduction from 300 to <50
• >69 dB: A reduction from 200 to <50
• >72 dB: No discernible difference (<50 to <50)

2050 $L_{Aeq\ 16\ hour}$
• >54 dB: An increase of 17,000 (from 7,600 to 24,600)
• >57 dB: An increase of 4,400 (from 2,800 to 7,200)
• >60 dB: An increase of 1,600 (from 1,200 to 2,800)
• >63 dB: An increase of 300 (from 500 to 800)
• >66 dB: A reduction of 100 (from 300 to 200)
• >69 dB: A reduction from 200 to <50
• >72 dB: No discernible difference (from <50 to <50)

2030 $L_{Aeq\ 8\ hour}$
• >48 dB: An increase of 10,600 (from 11,700 to 22,300)
• >51 dB: An increase of 900 (from 5,600 to 6,500)
• >54 dB: An increase of 1,200 (from 1,700 to 2,900)
• >57 dB: An increase of 200 (from 600 to 800)
• >60 dB: A reduction of 200 (from 400 to 200)
• >63 dB: A reduction from 300 to <50
• >66 dB: No discernible difference (from <50 to <50)
• >69 dB: No discernible difference (from <50 to <50)
• >72 dB: No discernible difference (from <50 to <50)

2040 $L_{Aeq\ 8\ hour}$
• >48 dB: An increase of 6,300 (from 11,100 to 17,400)
• >51 dB: A reduction of 300 (from 5,500 to 5,200)
• >54 dB: An increase of 600 (from 1,700 to 2,300)
• >57 dB: A reduction of 100 (from 600 to 500)
• >60 dB: A reduction of 300 (from 400 to 100)
• >63 dB: A reduction from 300 to <50
• >66 dB: No discernible difference (from <50 to <50)
• >69 dB: No discernible difference (from <50 to <50)
• >72 dB: No discernible difference (from <50 to <50)

2050 $L_{Aeq\ 8\ hour}$
• >48 dB: An increase of 7,400 (from 11,200 to 18,600)
• >51 dB: A reduction of 200 (from 5,600 to 5,400)
• >54 dB: An increase of 700 (from 1,700 to 2,400)
• >57 dB: An increase of 100 (from 600 to 700)
• >60 dB: A reduction of 300 (from 400 to 100)

• >63 dB: A reduction from 300 to <50
• >66 dB: No discernible difference (from <50 to <50)
• >69 dB: No discernible difference (from <50 to <50)
• >72 dB: No discernible difference (from <50 to <50)

2.5.1.2. Heathrow-NWR

For Heathrow-NWR-T, the estimated population exposed to day-time noise levels greater than 54dB $L_{Aeq\ 16\ hour}$ is 456,200 in 2030, 488,600 in 2040, and 491,900 in 2050. The estimated population exposed to night-time noise levels greater than 48dB $L_{Aeq\ 8\ hour}$ is 266,800 in 2030, 308,500 in 2040 and 295,800 in 2050.

Table 2.2. Estimated population exposed to levels greater than 54dB $L_{Aeq\ 16\ hour}$ and $L_{Aeq\ 8\ hour}$ in 2030, 2040, & 2050 for Heathrow-NWR-T.

	Heathrow-NWR-T		
	2030	**2040**	**2050**
Day-time			
54dB $L_{Aeq\ 16\ hour}$	456,200	488,600	491,900
57dB $L_{Aeq\ 16\ hour}$	237,100	249,900	249,300
60dB $L_{Aeq\ 16\ hour}$	128,200	137,000	140,600
63dB $L_{Aeq\ 16\ hour}$	38,300	41,300	42,900
66dB $L_{Aeq\ 16\ hour}$	1,200	11,800	10,900
69dB $L_{Aeq\ 16\ hour}$	900	900	800
72dB $L_{Aeq\ 16\ hour}$	<50	<50	<50
Night-time			
48dB $L_{Aeq\ 8\ hour}$	266,800	308,500	295,800
51dB $L_{Aeq\ 8\ hour}$	167,200	188,800	185,600
54 dB $L_{Aeq\ 8\ hour}$	72,200	95,700	88,600
57dB $L_{Aeq\ 8\ hour}$	11,600	18,100	12,100
60dB $L_{Aeq\ 8\ hour}$	900	2,400	900
63dB $L_{Aeq\ 8\ hour}$	200	200	200
66dB $L_{Aeq\ 8\ hour}$	<50	<50	<50
69dB $L_{Aeq\ 8\ hour}$	<50	<50	<50
72dB $L_{Aeq\ 8\ hour}$	<50	<50	<50

The differences in the 2030, 2040, and 2050 Do-Something scenarios compared with the 2030, 2040, and 2050 Do-Minimum scenarios are summarized below for day-time and night-time exposure. Generally, the estimates for the population exposed in the Do-Something scenarios for Heathrow-NWR-T in the day-time are higher than the estimates for the Do-Minimum scenarios in 2030, 2040 and 2050: there is an increase in the population exposed at the lower contour levels for $L_{Aeq\ 16\ hour}$ along with a slight reduction in the population exposed at the higher contour levels. For night-noise the population exposed to >48dB $L_{Aeq\ 8\ hour}$ is reduced for the Do-Something scenarios compared with the Do-Minimum scenarios at 2030, 2040 and 2050. In 2030 and 2040, there is an increase in the population exposed to >51dB and >54dB $L_{Aeq\ 8\ hour}$ but reductions are estimated for all the other $L_{Aeq\ 8\ hour}$ exposure contours. For the 2050 scenario the number of the population exposed at night-time is reduced across all the contours.

2030 $L_{Aeq\ 16\ hour}$
• >54 dB a decrease of 37,400 (from 493,600 to 456,200)
• >57 dB an increase of 15,900 (from 221,200 to 237,100)
• >60 dB an increase of 19,200 (from 109,000 to 128,200)
• >63 dB an increase of 3,100 (from 35,200 to 38,300)
• >66 dB an increase of 4,100 (from 7,900 to 12,000)
• >69dB a reduction of 1,200 (from 2,100 to 900)
• >72 dB no discernible difference (from <50 to <50)

2040 $L_{Aeq\ 16\ hour}$
• >54 dB an increase of 28,000 (from 460,600 to 488,600)
• >57 dB an increase of 30,500 (from 219,400 to 249,900)
• >60 dB an increase of 33,200 (from 103,800 to 137,000)
• >63 dB an increase of 7,400 (from 33,900 to 41,300)
• >66 dB an increase of 4,700 (from 7,100 to 11,800)
• >69 dB a reduction of 1,200 (from 2,100 to 900)
• >72 dB no discernible difference (from <50 to <50)

2050 $L_{Aeq\ 16\ hour}$
• >54 dB an increase of 56,100 (from 435,800 to 491,900)
• >57 dB an increase of 29,700 (from 219,600 to 249,300)
• >60 dB an increase of 36,800 (from 103,800 to 140,600)
• >63 dB an increase of 8,000 (from 34,900 to 42,900)
• >66 dB an increase of 3,200 (from 77,00 to 10,900)
• >69 dB a reduction of 1,300 (from 2,100 to 800)
• >72 dB no discernible difference (from <50 to <50)

2030 $L_{Aeq\ 8\ hour}$
• >48 dB a reduction of 4,400 (from 271,200 to 266,800)
• >51 dB an increase of 15,900 (from 151,300 to 167,200)
• >54 dB an increase of 11,100 (from 61,100 to 72,200)
• >57 dB a reduction of 10,300 (from 21,900 to 11,600)
• >60 dB a reduction 3,000 (from 3,900 to 900)
• >63 dB a reduction of 1,100 (from 1,300 to 200)
• >66 – 72 dB no discernible differences (all remain at <50 in both scenarios)

2040 $L_{Aeq\ 8\ hour}$
• >48 dB a reduction of 28,500 (from 337,000 to 308,500)
• >51 dB an increase of 4,200 (from 184,600 to 188,800)
• >54 dB an increase of 14,400 (from 813,00 to 95,700)
• >57 dB a reduction of 13,300 (from 31,400 to 18,100)
• >60 dB a reduction of 4,000 (from 6,400 to 2,400)

• >63 dB a reduction of 2,200 (from 2,400 to 200)
• >66 – 72 dB no discernible differences (all remain at <50 in both scenarios)

2050 $L_{Aeq\ 8\ hour}$
• >48 dB a reduction of 7,730 (from 373,100 to 295,800)
• >51 dB a reduction of 11,800 (from 197,400 to 185,600)
• >54 dB a reduction of 600 (from 89,200 to 88,600)
• >57 dB a reduction of 21,800 (from 33,900 to 12,100)
• >60 dB a reduction of 6,200 (from 7,100 to 900)
• >63 dB a reduction of 2,400 (from 2,600 to 200)
• >66 – 72 dB no discernible differences (all remain at <50 in both scenarios)

2.5.1.3. Heathrow-ENR

For Heathrow-ENR-O (using the offset flight path results), the estimated population exposed to day-time noise levels greater than 54dB $L_{Aeq\ 16\ hour}$ is 480,300 in 2030, 488,900 in 2040 and 462,900 in 2050. The estimated population exposed to night-time noise levels greater than 48dB $L_{Aeq\ 8\ hour}$ is 263,800 in 2030, 298,900 in 2040 and 306,700 in 2050.

Table 2.3. Estimated population exposed to levels greater than 54dB $L_{Aeq\ 16\ hour}$ and $L_{Aeq\ 8\ hour}$ in 2030, 2040, & 2050 for Heathrow-ENR-O.

	Heathrow-ENR-O		
	2030	**2040**	**2050**
Day-time			
54dB $L_{Aeq\ 16\ hour}$	480,300	488,900	462,900
57dB $L_{Aeq\ 16\ hour}$	257,900	264,700	261,200
60dB $L_{Aeq\ 16\ hour}$	157,500	164,400	165,500
63dB $L_{Aeq\ 16\ hour}$	63,700	67,500	67,100
66dB $L_{Aeq\ 16\ hour}$	17,100	17,700	17,800
69dB $L_{Aeq\ 16\ hour}$	3,900	4,000	3,900
72dB $L_{Aeq\ 16\ hour}$	600	700	600
Night-time			
48dB $L_{Aeq\ 8\ hour}$	263,800	298,900	306,700
51dB $L_{Aeq\ 8\ hour}$	177,400	193,800	197,200
54 dB $L_{Aeq\ 8\ hour}$	87,800	107,300	110,300
57dB $L_{Aeq\ 8\ hour}$	31,000	36,900	36,400
60dB $L_{Aeq\ 8\ hour}$	4,900	6,800	6,200
63dB $L_{Aeq\ 8\ hour}$	800	1,600	1,600
66dB $L_{Aeq\ 8\ hour}$	200	300	200
69dB $L_{Aeq\ 8\ hour}$	<50	100	<50
72dB $L_{Aeq\ 8\ hour}$	<50	<50	<50

The number of people within the day-time $L_{Aeq\ 16\ hour}$ noise contours are greater in the Heathrow-ENR-O Do-Something scenarios, when compared to the Do-Minimum scenarios, for all of the assessment years considered. For night-noise the population exposed to >48dB $L_{Aeq\ 8\ hour}$ and >63 $L_{Aeq\ 8\ hour}$ is reduced for the Do-Something scenario compared with the Do-Minimum scenario at 2030, 2040 and 2050, however, within the other exposure contours there are increases in the population exposed to night-noise.

2030 $L_{Aeq\ 16\ hour}$

- >54 dB: A reduction of 13,300 (from 493,600 to 480,300)
- >57 dB: An increase of 36,700 (from 221,200 to 257,900)
- >60 dB: An increase of 48,500 (from 109,000 to 157,500)
- >63 dB: An increase of 28,500 (from 35,200 to 63,700)
- >66 dB: An increase of 9,200 (from 7,900 to 17,100)
- >69 dB: An increase of 1,800 (from 2,100 to 3,900)
- >72 dB: An increase from <50 to 600

2040 $L_{Aeq\ 16\ hour}$

- >54 dB: An increase of 28,300 (from 460,600 to 488,900)
- >57 dB: An increase of 45,300 (from 219,400 to 264,700)
- >60 dB: An increase of 60,600 (from 103,800 to 164,400)
- >63 dB: An increase of 33,600 (from 33,900 to 67,500)
- >66 dB: An increase of 10,600 (from 7,100 to 17,700)
- >69 dB: An increase of 1,900 (from 2,100 to 4,000)
- >72 dB: A change from <50 to 700

2050 $L_{Aeq\ 16\ hour}$

- >54 dB: An increase of 27,100 (from 435,800 to 462,900)
- >57 dB: An increase of 41,600 (from 219,600 to 261,200)
- >60 dB: An increase of 61,700 (from 103,800 to 165,500)
- >63 dB: An increase of 32,200 (from 34,900 to 67,100)
- >66 dB: An increase of 10,100 (from 7,700 to 17,800)
- >69 dB: An increase of 1,800 (from 2,100 to 3,900)
- >72 dB: A change from <50 to 600

2030 $L_{Aeq\ 8\ hour}$

- >48 dB: A reduction of 7,400 (from 271,200 to 263,800)
- >51 dB: An increase of 26,100 (from 151,300 to 177,400)
- >54 dB: An increase of 26,700 (from 61,100 to 87,800)
- >57 dB: An increase of 9,100 (from 21,900 to 31,000)
- >60 dB: An increase of 1,000 (from 3,900 to 4,900)
- >63 dB: A reduction of 500 (from 1,300 to 800)
- >66 dB: An increase from <50 to 200
- >69 dB: No discernible change (from <50 to <50)
- >72 dB: No discernible change (from <50 to <50)

2040 $L_{Aeq\ 8\ hour}$

- >48 dB: A reduction of 38,100 (from 337,000 to 298,900)
- >51 dB: An increase of 9,200 (from 184,600 to 193,800)
- >54 dB: An increase of 26,000 (from 81,300 to 107,300)
- >57 dB: An increase of 5,500 (from 31,400 to 36,900)
- >60 dB: An increase of 400 (from 6,400 to 6,800)
- >63 dB: A reduction of 800 (from 2,400 to 1,600)
- >66 dB: An increase from <50 to 300
- >69 dB: An increase from <50 to 100
- >72 dB: No discernible change (from <50 to <50)

2050 $L_{Aeq\ 8\ hour}$

- >48 dB: A reduction of 66,400 (from 373,100 to 306,700)
- >51 dB: A reduction of 200 (from 197,400 to 197,200)
- >54 dB: An increase of 21,100 (from 89,200 to 110,300)
- >57 dB: An increase of 2,500 (from 33,900 to 36,400)
- >60 dB: A reduction of 900 (from 7,100 to 6,200)
- >63 dB: A reduction of 1,000 (from 2,600 to 1,600)
- >66 dB: An increase from <50 to 200
- >69 dB: An increase from <50 to <50
- >72 dB: No discernible change (from <50 to <50)

2.5.2. Mitigation

All the schemes suggest mitigation activities for their schemes. Aspects to note are as follows:

- Gatwick 2-R: houses within the 60 $L_{Aeq\ 16\ hour}$ contour will be offered £3,000 towards double glazing and loft insulation for newly affected homes. Residents with a home within the 57dB $L_{Aeq\ 16\ hour}$ contour will be offered £1000 per annum – to qualify residents must have been living in the house before 1^{st} January 2015.
- Heathrow-NWR: runway operations allow respite for local populations. Residents in the 60dB $L_{Aeq\ 16\ hour}$ contour will be offered full-costs for insulation; residents exposed to 55dB L_{den} will be offered a £3,000 contribution towards insulation.
- Heathrow ENR: the promoter is not advocating night-time operation of the extended runway and is also planning to reduce day-time exposure by use of noise preferential routing. This scheme will also offer full-costs for home insulation for residents in the 60dB $L_{Aeq\ 16\ hour}$ contour, with residents in the 55dB L_{den} contour offered a £3,000 contribution towards insulation.

In terms of mitigation, very little is understood in terms of how monetary payments or respite from exposure might influence the associations between aircraft noise and health. The health-benefits associated with many of these activities should not be assumed and need to be empirically tested. The impact of any mitigation scheme would ideally be evaluated to assess efficacy and cost-effectiveness.

2.5.3. Implications of the noise effects on health evidence for the proposed schemes

A brief consideration of the evidence for noise effects on health in relation to the three schemes is provided below:

- Aircraft noise exposure is associated with small increases in risk for poor cardiovascular health outcomes such as high blood pressure, heart attacks, and stroke, as well as with cardiovascular hospital admission and cardiovascular mortality, with effects observed for day-time ($L_{Aeq\ 16\ hour}$) and night-time ($L_{Aeq\ 8\ hour}$) exposure.

- Whilst the increase in risk observed between aircraft noise exposure and cardiovascular health is considered moderate, such increases in risk become important if a large population is exposed to aircraft noise.

- Night-noise is associated with self-reported sleep disturbance and with changes in sleep structure. Night-noise might also be particularly important for cardiovascular effects. Populations exposed to night-time noise could benefit from insulation of their home. It may also be beneficial to consider the use of curfews for night-noise flights: respite may also be effective but needs empirically evaluating.

- Aircraft noise exposure during the evening and early morning (outside the typical 23.00 to 07.00 8 hour night exposure metric) also has relevance for the health and sleep quality of the local population, and may be particularly relevant for children, the physically ill, and shift-workers. Therefore the impact of aircraft noise on the sleep of the local population may not be restricted only to the night-time period and insulation to the homes of populations exposed to day-time noise levels might also be beneficial.

- Consideration should be given to health monitoring of cardiovascular risk factors in the exposed population: for example, high blood pressure and cholesterol can be treated with medication to avoid more serious cardiovascular disease progression. This can probably be achieved through existing NHS Health Checks offered to individuals aged 40-74 by their GPs, which checks vascular and circulatory health.

- Aircraft noise annoyance responses are to be expected for children and adults and it should be borne in mind that annoyance responses in relation to exposure may be higher than predicted by the traditional annoyance curves. In particular, annoyance can increase in relation to operational changes; where populations become newly exposed to noise; where populations experience a step-change in exposure; and in response to early morning and evening flights. Monitoring of annoyance responses over the long-term using survey methods in the exposed population would be advisable. In particular, annoyance responses at different times of the day should be examined. Surveys assessing baseline annoyance, in terms of annoyance responses prior to the development of the new runway would be useful for comparative purposes. Such monitoring would help the airport to identify any increases in annoyance related to operational decisions.

- Based on current evidence aircraft noise might be associated with decreased quality of life but is unlikely to be causing psychological ill-health. The increases in hyperactivity symptoms observed for children are small and unlikely to be of clinical significance in the population exposed. The evidence relating to aircraft noise effects on psychological health should be re-reviewed throughout the planning process, as further evidence becomes available.

3. Aircraft noise effects on children's cognition and learning

3.1. Reading and memory

Many studies have found effects of aircraft noise exposure at school or at home on children's reading comprehension or memory skills (Evans & Hygge, 2007). The RANCH study (Road traffic and Aircraft Noise and children's Cognition & Health) of 2844 9-10 year old children from 89 schools around London Heathrow, Amsterdam Schiphol, and Madrid Barajas airports found that aircraft noise was associated with poorer reading comprehension and poorer recognition memory, after taking social position and road traffic noise, into account (Stansfeld et al., 2005).

Figure 3.1 shows the exposure-effect relationship between aircraft noise at school and reading comprehension from the RANCH study (Clark et al., 2006), indicating that as aircraft noise exposure increased, performance on the reading test decreased. Reading began to fall below average at around 55dB $L_{Aeq\ 16\ hour}$ at school but as the association is linear, (thus there is no specific threshold above which noise effects begin) any reduction in aircraft noise exposure at schools should lead to an improvement in reading comprehension, supporting a policy to not only insulate schools exposed to the highest levels of aircraft noise. The development of cognitive skills such as reading and memory is important not only in terms of educational achievement but also for subsequent life chances and adult health (Kuh & Ben-Shlomo, 2004). In the UK, reading age was delayed by up to 2 months for a 5dB increase in aircraft noise exposure (Clark et al., 2006). The UK primary schools in the RANCH study ranged in aircraft noise exposure from 34dB $L_{Aeq\ 16\ hour}$ to 68 dB $L_{Aeq\ 16\ hour}$. If we take a 20dB difference in aircraft noise exposure between schools, the study would estimate an 8-month difference in reading age.

For primary school children, aircraft noise exposure at school and at home are very highly correlated: in the RANCH UK sample, this correlation was r=0.91 (Clark et al., 2006). Such a high correlation can make estimating the impact of aircraft noise exposure in both environments difficult. The RANCH study found that night-time aircraft noise at the child's home was also associated with impaired reading comprehension and recognition memory, but night-noise was not having an additional effect to that of day-time noise exposure on reading comprehension or recognition memory (Clark et al., 2006; Stansfeld et al., 2010). These findings suggest that indices of aircraft noise exposure in the day-time in the school environment should be sufficient to capture effects. Further analyses of the UK RANCH sample found that these associations for aircraft noise exposure remained after taking co-occurring air pollution levels into account (Clark et al., 2012).

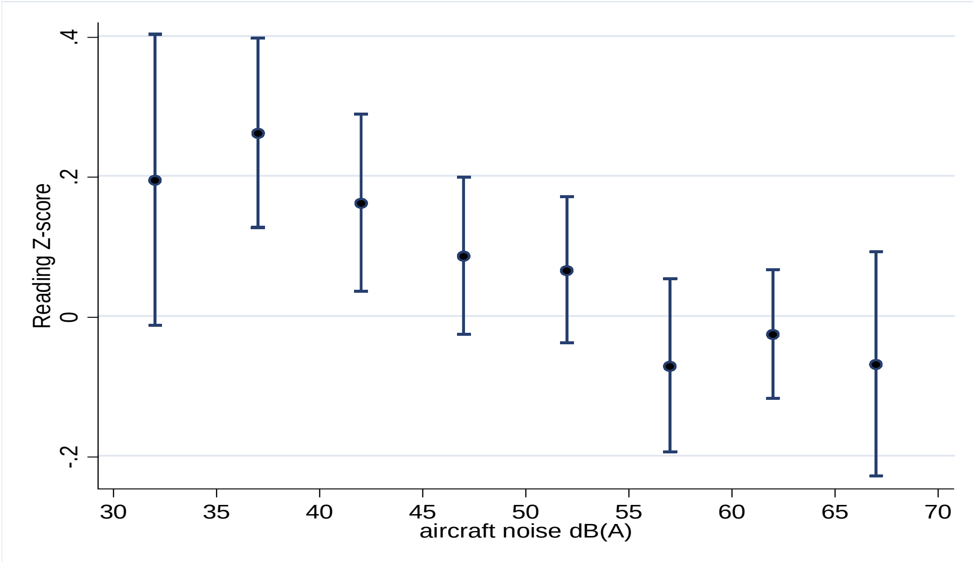

Figure 3.1. Exposure-effect relationship between aircraft noise exposure at school and reading comprehension in the RANCH study (Clark et al., 2006).

There are several ways in which aircraft noise could influence children's cognition: lost teaching time - as a teacher may have to stop teaching whilst noise events occur; teacher and pupil frustration; annoyance and stress responses; reduced morale; impaired attention; children might tune out the aircraft noise and over-generalise this response to other sounds in their environment missing out on information; and sleep disturbance from home exposure which might cause performance effects the next day (Stansfeld & Clark, 2015).

Children spend a considerable amount of time at school in the playground. Play is thought to be important for children's social, cognitive, emotional and physical development, as well as enabling relaxation between more formal teaching activities. Unfortunately, at this time, there is no empirical evidence upon which to draw conclusions about how aircraft noise exposure might impact upon children's use of playground settings.

3.2. School intervention studies

Two studies of interventions to reduce or remove aircraft noise exposure at school are worth noting. The longitudinal Munich Airport study (Hygge et al., 2002) found that prior to the relocation of the airport in Munich, high noise exposure was associated with poorer long-term memory and reading comprehension in children aged 10 years. Two years after the airport closed these cognitive impairments were no longer present, suggesting that the effects of aircraft noise on cognitive performance may be reversible if the noise stops. In the cohort of children living near the newly opened Munich airport impairments in memory and reading developed over the following two years.

A recent study of 6,000 schools exposed between the years 2000-2009 at the top 46 United States airports, (exposed to Day-Night-Average Sound Level of 55dB or higher) found significant associations between aircraft noise and standardised tests of mathematics and reading, after taking demographic and school factors into account (Sharp et al., 2014). In a sub-sample of 119 schools, they found that the effect of aircraft noise on children's learning disappeared once the school had sound insulation installed. This study supports a policy for insulating schools that may be exposed to high levels of aircraft noise associated with a new runway.

3.3. Implications of the evidence for aircraft noise effects on children's cognition and learning for the proposed schemes

It is clear from the research studies that aircraft noise exposure at school is associated with children' having poorer reading and memory skills. Further, evidence is emerging that confirms the use of insulation to mitigate against these effects, and which ever scheme is undertaken, there should be a commitment to insulate schools exposed to high levels of aircraft noise in the day-time.

Schools located near airports often also experience high levels of road traffic noise but it is important to appreciate that aircraft noise exposure still influences children's learning, even if road traffic noise exposure is high. The results presented for the RANCH study are the association for aircraft noise exposure, after taking road traffic noise into account (Clark et al., 2006).

For each of the shortlisted options an estimate of the change in the number of sensitive buildings, including schools, within each contour between the Do-Minimum and the Do-Something scenarios has been made. Below a summary is given of the difference in the number of schools in the Do-Minimum scenario and the Do-Something scenario for each scheme, focusing on day-time noise exposure which best represents exposure during the school day. It should be noted that these figures do not represent the total number of schools impacted by the schemes: the figures are restricted to schools whose exposure is changed by the scheme.

3.3.1. Gatwick 2-R

Gatwick Airport Limited (GAL) states that it hopes that no new noise sensitive buildings would be given planning consent in the areas with the highest noise contours. It is estimated that in 2030, compared with the Do-Minimum scenario, that there will be 5 additional schools exposed to >54dB $L_{Aeq\ 16\ hour}$; in 2040 there will be 7 additional schools exposed to >54dB $L_{Aeq\ 16\ hour}$; and in 2050 14 additional schools exposed to >54dB $L_{Aeq\ 16\ hour}$. There will also be a small reduction in the number of schools exposed to >60dB and 63dB $L_{Aeq\ 16\ hour}$ in 2030, 2040, and 2050: in 2030 there will also be a small reduction in the number of schools exposed to 57dB $L_{Aeq\ 16\ hour}$.

The N70 metrics for the schools are at the lower end for all years, with schools mostly exposed to N70>20. These school exposed to aircraft noise associated with Gatwick 2-R would be at the lower-end of the N70 contours, but should be insulated to protect again effects on children's learning. There is a small reduction in the number of schools exposed to N70>200 in 2030, 2040, and 2050: small reductions are also seen for the number of schools exposed to N70>100 in 2030 and 2040, and for N70>50 in 2030.

Table 3.1. Number of schools in the Do-Something Scenarios for Gatwick 2-R compared with the Do-Minimum scenarios.

	Gatwick 2-R		
	2030	**2040**	**2050**
Day-time			
54dB $L_{Aeq\ 16\ hour}$	5	7	14
57dB $L_{Aeq\ 16\ hour}$	(1)	(1)	2
60dB $L_{Aeq\ 16\ hour}$	(1)	(1)	(1)
63dB $L_{Aeq\ 16\ hour}$	(2)	(2)	(1)
66dB $L_{Aeq\ 16\ hour}$	0	0	0
69dB $L_{Aeq\ 16\ hour}$	0	0	0
72dB $L_{Aeq\ 16\ hour}$	0	0	0
N70			
N70>20	7	6	8
N70>50	(1)	2	2
N70>100	(1)	(1)	0
N70>200	(1)	(1)	(1)
N70>500	0	0	0

Numbers in parentheses indicate a reduction in the number of schools within that noise contour.

3.3.2. Heathrow-NWR

It is estimated that in 2030, compared with the Do-Minimum scenario, that there will be 49 fewer schools exposed to 54dB $L_{Aeq\ 16\ hour}$. In 2040 it is estimated that there will be 12 additional schools exposed to >54dB $L_{Aeq\ 16\ hour}$ and in 2050 24 additional schools exposed to >54dB $L_{Aeq\ 16\ hour}$.

In 2030 there is a reduction of 2 in the number of schools exposed to N70>20. However, there are increases in the number of schools exposed to N70>20 in 2040 and 2050, and for N70>50, N70>100 and N70>200 in 2030, 2040 and 2050. There is also a small increase (n=2) in the number of schools exposed to N70>500 in 2040 and 2050. Schools experiencing a high number of events over 70dB would benefit from being included in insulation schemes.

Table 3.2. Number of schools in the Do-Something Scenarios for Heathrow-NWR-T compared with the Do-Minimum scenarios.

	Heathrow-NWR-T		
	2030	**2040**	**2050**
Day-time			
54dB $L_{Aeq\ 16\ hour}$	(49)	12	24
57dB $L_{Aeq\ 16\ hour}$	15	22	15
60dB $L_{Aeq\ 16\ hour}$	17	22	23
63dB $L_{Aeq\ 16\ hour}$	1	1	1
66dB $L_{Aeq\ 16\ hour}$	2	3	4
69dB $L_{Aeq\ 16\ hour}$	1	1	1
72dB $L_{Aeq\ 16\ hour}$	0	0	0
N70			
N70>20	(2)	11	12
N70>50	6	11	9
N70>100	8	16	13
N70>200	4	10	14
N70>500	0	2	2

Numbers in parentheses indicate a reduction in the number of schools within that noise contour.

3.3.3. Heathrow-ENR

Using the offset flight path results, it is estimated that in 2030, compared with the Do-Minimum scenario, that there would be a reduction of 22 schools exposed to >54dB $L_{Aeq\ 16\ hour}$ in 2030. In 2040 it is estimated that there will be 25 additional schools exposed to >54dB $L_{Aeq\ 16\ hour}$ and in 2050 13 additional schools exposed to >54dB $L_{Aeq\ 16\ hour}$.

Compared with the Do-Minimum scenario, there would be increase in the number of schools exposed to N70>20, with 16 additional schools exposed in 2030, 29 additional schools in 2040, and 19 additional schools in 2050. For the Heathrow-ENR-O scheme there is also an increase in the number of additional schools exposed to N70>50, N70>100, and N70>200 in 2030, 2040 and 2050. Schools experiencing a high number of events over 70dB would benefit from being included in insulation schemes.

Table 3.3. Number of schools in the Do-Something Scenarios for Heathrow-ENR-O compared with the Do-Minimum scenarios.

	Heathrow-ENR-O		
	2030	**2040**	**2050**
Day-time			
54dB $L_{Aeq\ 16\ hour}$	(22)	25	13
57dB $L_{Aeq\ 16\ hour}$	22	34	32

60dB $L_{Aeq\ 16\ hour}$	36	40	39
63dB $L_{Aeq\ 16\ hour}$	11	12	12
66dB $L_{Aeq\ 16\ hour}$	3	2	3
69dB $L_{Aeq\ 16\ hour}$	2	2	2
72dB $L_{Aeq\ 16\ hour}$	0	0	0
N70			
N70>20	16	29	19
N70>50	19	25	24
N70>100	12	17	19
N70>200	23	27	27
N70>500	0	0	0

Numbers in parentheses indicate a reduction in the number of schools within that noise contour.

3.4. Discussion

The Gatwick 2-R scheme results in a small number of additional schools being exposed to >54dB $L_{Aeq\ 16\ hour}$ in each year. Both of the Heathrow schemes are initially associated with a reduction in the number of schools exposed to 54dB $L_{Aeq\ 16\ hour}$ (49 fewer schools for Heathrow-NWR and 22 fewer schools for Heathrow-ENR), but in subsequent years (2040 & 2050) both schemes would result in additional schools being exposed to 54dB $L_{Aeq\ 16\ hour}$. The number of schools additionally exposed to 54dB $L_{Aeq\ 16\ hour}$ in 2040 is 12 for Heathrow-NWR and 29 for Heathrow-ENR. The number of schools additionally exposed to 54dB $L_{Aeq\ 16\ hour}$ in 2050 is 24 for Heathrow-NWR and 13 for Heathrow-ENR. Over-time both of the Heathrow schemes would result in a considerable increase in the number of schools in the surrounding area being exposed to aircraft noise. Both schemes also result in a small number of additional schools being exposed at the higher ends of the contours.

Whilst Gatwick impacts on fewer additional schools, funding for the insulation of schools additionally exposed to aircraft noise over the process of extending the airport operation (whether it be Gatwick 2R, Heathrow-NWR, or Heathrow-ENR) would need to be found. For example, at present the Heathrow-NWR scheme has £19 million included to insulate schools. Schools exposed would be insulated as they fell into the noise contours. Currently, schools around Heathrow airport are insulated if they are exposed to 63dB $L_{Aeq\ 16\ hour}$. Consideration should be given, particularly for schools experiencing an increase in their average noise exposure and therefore subject to a step-change in exposure, to insulating schools exposed to a high level of aircraft noise. Consideration should also be given to including schools experiencing a high number of events over 70dB in the insulation programme. It is important that any insulation programme for schools is fully-funded and managed over the decades, as the number of schools affected by aircraft noise increases with the operation of some of the schemes, despite initially decreasing the number of schools exposed. Such a large-scale insulation plan of schools should also be evaluated empirically to ensure its effectiveness.

It is important to note that the figures in relation to the number of schools exposed to aircraft noise discussed in this section, do not include schools that may already be exposed to levels above 54dB $L_{Aeq\ 16\ hour}$ or N70>20 prior to the additional runway being commissioned, and/or which may already have been insulated via existing mitigation schemes. It is advisable that all schools within the contours identified as eligible for mitigation, whether newly exposed or already exposed to aircraft noise be offered access to the same insulation programme.

4. Guidelines for Environmental Noise Exposure

4.1. The WHO Community Noise Guidelines

There are recommended guidelines for environmental noise exposure levels. The most influential set of guidelines are those proposed by the World Health Organisation Europe back in 2000 (WHO, 2000), which were determined by expert panels evaluating the strength of the evidence and suggesting guideline values for thresholds for exposure in specific dwellings and for specific health effects. Below is a summary of the guideline levels suggested for dwellings, schools & pre-schools, hospitals, and parkland:

DWELLINGS
Day-time
- Indoors the dwelling during the day/evening – 35 dB $L_{Aeq\ 16\ hour}$
- Outdoor living areas - 55 dB $L_{Aeq\ 16\ hour}$ to protect the majority of people from being 'seriously annoyed' during the day-time.
- Outdoor living areas – 50 dB $L_{Aeq\ 16\ hour}$ to protect the majority of people from being 'moderately annoyed' during the day-time

Night-time
- Outside façades of the living spaces should not exceed 45 dB $L_{Aeq\ 8\ hour}$ and 60 dB L_{Amax} to protect from sleep disturbance.
- Inside bedrooms - 30 dB $L_{Aeq\ 8\ hour}$ and 45 dB L_{Amax} for single sound events to protect from sleep disturbance.

SCHOOLS & PRE-SCHOOL
- School playgrounds outdoors should not exceed 55 dB L_{Aeq} during play to protect from annoyance.
- School classrooms should not exceed 35 dB L_{Aeq} during class to protect from speech intelligibility and, disturbance of information extraction.
- The reverberation time in the classroom should be about 0.6 s.
- Pre-school bedrooms – 30 dB during sleeping time & 45 dB L_{Amax} for single sound events to protect from sleep disturbance.

HOSPITALS

Day-time

- Hospital ward rooms indoor values during the day-time/evening - 30 dB $L_{Aeq\ 16\ hour}$ to protect from sleep disturbance and interference with rest and recovery.

Night-time

- Hospital ward rooms indoor values at night - 30 dB $L_{Aeq\ 8\ hour}$, together with 40 dB L_{Amax} to protect from sleep disturbance and interference with rest and recovery.

PARKLAND AND CONSERVATION AREAS

- Existing large quiet outdoor areas should be preserved and the signal-to-noise ratio kept low.

Below these noise levels, it is thought there are no detrimental effects on health.

The WHO Community Guidelines represent a 'precautionary principle' approach to environmental noise effects on health and the WHO Community Guidelines are often thought by policy makers and acousticians to be very difficult to achieve in practice. It is also worth noting that when these guidelines were established in the late 1990s the evidence-base for noise effects on cardiovascular health and children's cognition was much weaker and that these effects per se, did not inform the guidelines. The WHO plans to publish a revision of these guidelines in 2015, so it is worth stipulating that the revised guidelines should be considered in relation to school, home, hospital and any other settings affected by the new runway.

The number of hospitals identified as being impacted by aircraft noise is low for Gatwick-2R, Heathrow-NWR, and Heathrow-ENR, falling at the lower ends of the noise exposure contours. However, efforts to insulate these hospitals should be included in the planning consent for the successful scheme.

4.2. WHO Night Noise Guidelines

The WHO Europe Night Noise Guidelines (WHO, 2009) state that the target for nocturnal noise exposure should be 40 dB $L_{night,\ outside}$, which should protect the public as well as vulnerable groups such as the elderly, children, and the chronically ill from the effects of nocturnal noise exposure on health. The Night Noise Guidelines also recommend the level of 55 dB $L_{night,\ outside}$, as an interim target for countries wishing to adopt a step-wise approach to the guidelines.

4.3. Building Bulletin 93: Acoustic Design of Schools in the UK

For schools, it is also worth noting the requirements of recently updated Building Bulletin 93: Acoustic Design of Schools in the UK (DfE, 2015), which recommends external noise levels for new school buildings or refurbished school buildings should not exceed <60 dB LA, $_{30\ minutes}$.

5. Conclusion

The health effects of environmental noise are diverse, serious, and because of widespread exposure, very prevalent (Basner et al, 2014). For populations around airports, aircraft noise exposure can be chronic. Evidence is increasing to support preventive measures such as insulation, policy, guidelines, & limit values. Efforts to reduce exposure should primarily reduce annoyance, improve learning environments for children, and lower the prevalence of cardiovascular risk factors and cardiovascular disease (Basner et al, 2014).

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Location	direction	airline
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Departure	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Departure	AIN African International Airways
Unknown	Departure	AIN African International Airways
Unknown	Arrivals	MKA MK Airlines
Unknown	Departure	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	CLX Cargolux Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines
Unknown	Departure	MKA MK Airlines
Unknown	Arrivals	MKA MK Airlines

date	runway	aircraft	registration	lmax	db
05/01/2008 21:22:00	28	B742	GMKHA	99.4	91.8
13/01/2008 14:41:00	28	B742	9GMKM	97.7	91.8
18/01/2008 15:51:00	28	B742	TFARW	100	93.4
27/01/2008 09:11:00	28	B742	GMKFA	98.3	91
29/01/2008 15:49:00	28	B742	GMKGA	99.5	96.2
29/01/2008 20:27:00	10	B742	GMKGA	103	96.3
30/01/2008 13:13:00	28	B742	GMKHA	99.6	91.5
05/02/2008 13:26:00	28	B742	GMKCA	99.1	91.5
07/02/2008 14:07:00	28	B742	GMKGA	98.1	94.7
18/02/2008 22:19:00		DC85	ZSOSI	99.7	91.1
19/02/2008 18:39:00	10	DC86	ZSOSI	101	91.2
21/02/2008 10:40:00	28	B742	GMKDA	99.1	92.4
24/02/2008 00:47:00	10	B742	GMKBA	98.8	93.6
24/02/2008 08:10:00	28	B742	GMKBA	99	92.4
26/02/2008 17:47:00	28	B742	GMKHA	98.9	91.9
11/03/2008 14:28:00	28	B744	LXPCV	99	91.5
14/03/2008 18:25:00	28	B742	N704CK	98.6	91.9
18/03/2008 11:23:00	28	B742	GMKCA	98.1	92.2
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21/03/2008 00:18:00		B742	GMKBA	106	106.5

Lebensqualität
Gesundheit
Entwicklung

NORAH
Knowledge No. 1

NORAH Noise Impact Study

Child study: Effects of aviation noise on children

Task and method

forum flughafen & region
umwelt- und nachbarschaftshaus

NORAH

Knowledge No. 1

NORAH Noise Impact Study

Child study: Effects of aviation noise on children

Task and method

"NORAH Knowledge" provides information at irregular intervals about the methods and results of the NORAH noise impact study. The aim of this publication is to communicate to as many people as possible what exactly NORAH does. This why you will find an explanation in the glossary at the end of this edition for all items marked with an "▤". If you would like to receive further editions of "NORAH Knowledge", please use the attached order form.

The NORAH Child Study examines the chronic effects of aviation noise on primary school children. The study is concerned with the effects on the intellectual development of the children. It focuses on reading acquisition and on certain language skills that are important for learning to read. In order to find out more about these skills, the scientists had the 2nd grade schoolchildren at 29 primary schools solve a series of tasks in tests. The study also explores how well the children feel at school and at home, and to what extent aviation noise impacts on this wellbeing. The scientists surveyed not only the children themselves but also their parents and teachers. Now they are examining the links between the results of the tests and questionnaires on the one hand and the aviation noise on the other.

NORAH is the most extensive investigation into the effects of exposure to aviation, road and rail noise that has ever been carried out in Germany. It is being conducted by nine independent scientific institutes from all over Germany. The client is the Umwelt- und Nachbarschaftshaus, a subsidiary of the Land of Hessen and part of the Forum Frankfurt Airport and Region. Communities, Fraport AG and Lufthansa are also involved in the financing.

Contents

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The scientists' questions

Prof. Dr. Maria Klatte from the TU Kaiserslautern is investigating the effects of aviation noise on the cognitive development of primary school children.

"The intellectual development of children, in particular the development of the skills learned in school such as reading, is influenced by a wide range of factors to do with the family and the school. Educational research has shown this. Therefore, in order to examine the influence of aviation noise, we also have to look at the learning environment at home and in the school."

The psychologist Prof. Dr. Maria Klatte is responsible for this part of the NORAH Study. She is a scientist at the department of "Cognitive and Developmental Psychology" at the Technical University of Kaiserslautern. For more than 15 years now, Prof. Dr. Klatte has been examining the effects of noise on intellectual achievement, focusing on children for the last ten years. With her work for NORAH she wants to answer the following questions:

- Is it possible to definitively prove a negative impact of aviation noise on intellectual abilities such as learning to read, language abilities, attention or memory in children in the Rhine-Main Region?
- How exactly does aviation noise at the school impact on lessons?
- To what extent does the aviation noise influence the well-being of the children in the school and at home?
- How large is the influence of aviation noise compared with other factors?

Aviation noise and learning to read: What do we already know?

Various studies have already examined how aviation noise impacts on children. The knowledge gained up to now about this link can be summarized as follows:

- Some studies found a connection between aviation noise and poorer learning performance of children. They were unable, however, to reliably rule out that other factors may have been responsible for this result, for example the socioeconomic status of the parents. This depends largely on the level of education, profession and income (Glossary). In some cases the results were also contradictory (see section on the RANCH Study on page 10 f.).
- In those studies that established an influence of aviation noise on learning performance, this was most likely to affect the ability to read.
- It is possible that aviation noise does not influence the ability to read directly, but indirectly via so-called precursor skills (Glossary), i.e. via language abilities that the child needs to be able to learn to read well. This includes, for example, distinguishing between similar sounds, break down words into their individual elements and being able to store linguistic information in the short-term memory.

The challenge: Filtering out non-noise-related factors

PISA, IGLU and other educational studies have shown that there are a lot of different factors that affect how well a child learns at school. The reading performance of primary school children depends, for example, on the educational level and income of the parents (the so-called "socioeconomic status" Glossary), on a possible migration background or the abilities of the children to speak German. In addition to this, school-related factors such as the quality of the teaching and the class composition also play a role.

Some studies also point out that there are more people with a low education level or income living in the areas subject to the highest aviation noise exposure than in the quieter residential areas. Scientists describe this kind of overlap of various influencing factors as "confounding" (Glossary). Poorer reading performance in children exposed to high levels of aviation noise can therefore only be reliably attributed to the aviation noise if the socioeconomic status of the families is carefully considered in the statistical evaluation. The NORAH Study used a parent questionnaire to gather all of the necessary information on the family situation of the children.

Alongside these "non-noise-related influencing factors", there are other types of noise that have nothing to do with aviation. This is why NORAH also looked at road and rail noise at the home of the child and at the school. And as a very reverberant classroom can increase the noise levels during lessons, this factor was also taken into account. Such factors can also be confounded with the effect of aviation noise on children and thus falsify the results of the investigation.

The biggest challenge in the child module of the NORAH Study consists in identifying as precisely as possible the various influences on the learning performance of the children. This is the only way that the scientists can filter out which effects are caused by the aviation noise alone.

"More influencing factors were taken into consideration within the framework of NORAH than in any other study about the impact of aviation noise on children worldwide."

What exactly was investigated – and how?

Overview of investigated factors

Influencing factors	Method
Aviation noise at school and home	Calculated data from the NORAH Consortium
Road and rail noise at school and home	Calculated data from the NORAH Consortium
Building and room acoustics of the classrooms	Estimation procedure for determination of the reverberation time and noise insulation
Family-related influencing factors Socioeconomic status, migration background German-language skills in children with migration background	Preliminary survey of schools, parent questionnaire, assessment by teachers
School-related influencing factors Methods of teaching reading	Teacher questionnaire
Effect factors	**Method**
Reading ability and precursor skills Reading ability Long and short-term memory for linguistic information Sound processing Language perception Attention Non-language skills	Group test in the class
Quality of life and environment Wellbeing in the school and at home, class atmosphere	Child questionnaire, parent questionnaire, teacher questionnaire
Noise exposure in the school and at home	Child questionnaire, parent questionnaire, teacher questionnaire

Aviation noise

It is easy to measure how loud it is at a certain time at a certain place. But the question for the NORAH Child Study was: Can long-term exposure to aviation noise lead to a permanent impairment of the intellectual development of children? In simple terms: It is not about how loud it is in the classroom when the children are learning the letter A, but about whether continuous aviation noise has such an influence on the intellectual development of the children that they learn to read more slowly than children growing up in a quieter environment.
This is why NORAH needs noise levels that describe the exposure of the children at home and in the school over a prolonged period of time. The team around Prof. Dr. Klatte received this data from their partners in the NORAH-Consortium, who are responsible for acoustics and had evaluated radar data on all flight movements over the course of 15 years. This allowed them to calculate exact noise levels for various daytime and night-time periods at over 900,000 building addresses in the study region. Using anonymized code numbers of their participants, the child study team was able to link this noise data with their own results.

Building and room acoustics

The following values were measured directly in the classroom:

- **Reverberation time:** This is the time for which a noise reverberates in the classroom. In the case of long reverberation times, the noise level in the classroom increases, as all noises reverberate for longer; in addition to this, it is more difficult to hear voices (e.g. that of the teacher) due to the reverberation.

- **Insulation:** From the type and thickness of the windows and walls it was possible to deduce how well the classroom is protected against aviation noise when the windows are closed.

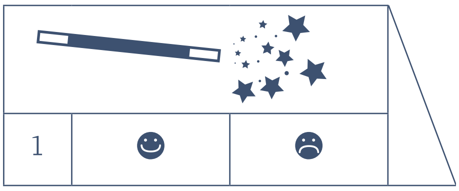
The acoustics were analyzed to rule out the confounding of the aviation noise exposure with poor classroom acoustics. The scientists examined whether the aviation noise had a different effect depending on the acoustic quality of the classrooms; for example, whether negative effects were minimized or completely eliminated in schools with very good noise insulation.

Reading ability

In order to find out how well the children can read, they completed a standardized reading test which is also used in other studies. The test focuses on the speed of reading and the level of understanding when reading words, sentences and short texts.

Short-term memory

The linguistic short-term memory plays an important role in reading. It ensures that by the time we reach the end of a sentence, we still know how it started. This applies in particular to children, who often still have to spell themselves through the words. But how can this be tested? The children listened through a headset to a fantasy word spoken by a “sorceress” (“magic word”), for example “Eulafing”, “Strobagel” or “Krefensal”. Immediately afterwards, they heard a “sorcerer’s apprentice” repeating the word. In their work sheet the children then had to cross whether the apprentice had repeated the word correctly or incorrectly.



Long-term memory

The children listened to a story read out to them and had to answer questions on it. Earlier studies on the impact of aviation noise on the long-term memory had given rise to contradictory findings. In order to pursue this more thoroughly, this factor was also examined by NORAH.

Awareness for syllables and phonetics ("phonological awareness")

In order for a child to learn how to read, he must understand how language and script function. A monkey is a monkey, the child knows that already. Now he has to learn that the word "monkey" is made up of two syllables and these syllables are made up of different sounds. In order to test this ability, the children had to listen to three artificial words (e.g. bann – beck – dimm). Then they had to identify which words started with the same sound.

Speech perception

The precise perception of speech is also a prerequisite for the ability to read and write. NORAH examined this ability with a hearing test: the children saw on a screen three pictures of objects with similar-sounding names, e.g. "bee, flea, sea". Then they heard a word through a headset (e.g. "bee") spoken in a confusion of voices. Then they had to put a cross on their answer sheet at the picture that corresponded to the spoken word.

"Aviation noise affects children not only in school."

Attention

For this task the children were shown a series of small pictures from which they had to cross out certain pictures in a short time.

Non-linguistic abilities

For this task the children were shown patterns, from each of which a jigsaw piece was missing. The children were to select the part missing from the pattern from six alternatives. This task tests the ability to draw conclusions on the basis of non-linguistic material. Such tasks are a feature of many intelligence tests. According to our present knowledge, aviation noise has no effect on this type of ability. The task was included in order to be able to show that any aviation noise effects on the reading ability are not due to differences in the general intellectual ability of the various children.

Quality of life and effects on lessons

Aviation noise affects children not only in school. It has effects on their whole life and their wellbeing. This is why NORAH also examined the quality of life of the schoolchildren. The information for this comes from two different points of view: On the one hand, the children themselves were asked how they would assess their wellbeing in different areas of their lives. On the other hand, the parents were asked how they would assess the situation of the children. Teachers also provided information about how they assess the effects of aviation noise on lessons.

"With the headset system we were able to exclude as far as possible factors that would hinder comprehension."

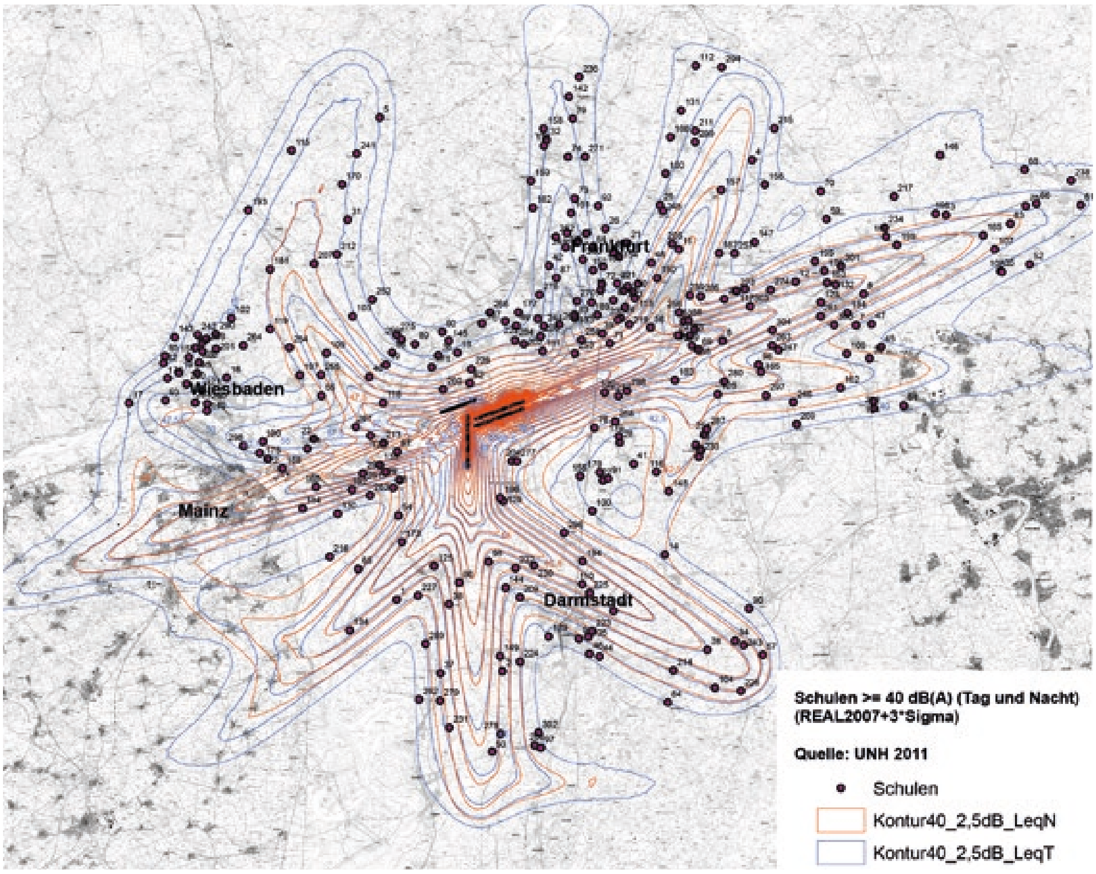
Photos: Bergström

Why tests with headphones?

In some of the tests the investigation team worked with a set of wireless headphones especially developed for children that were provided by the Hörzentrum Oldenburg. Some of the parents were surprised by this and asked whether that would not falsify the results. After all, the children do not have headphones in the classroom. Scientists always welcome such questions, as they represent an ideal opportunity to explain their work. This is what study director Prof. Dr. Klatte has to say:

"In the NORAH Study we are investigating the chronic effects of aviation noise on the intellectual development of children. Chronic effects are permanent impairments that can arise as a result of long-term exposure to aviation noise in the school and home environment. In short: How well will a child learn if he is taught for years in a school continuously exposed to the noise of low-flying aircraft? To test such chronic effects, e.g. on learning to read, it does not have to be loud in the test situation. In order to identify chronic effects, we have to compare the test results from children exposed to various levels of aviation noise with each other. We can only do this if we are certain that all of the children can understand the spoken words and syllables in the tasks equally well. By using headphones we can eliminate as far as possible factors that hinder comprehension, such as acute aviation noise, noise from adjacent rooms, reverberation time in the classrooms, or the distance of the child from the teacher's desk. To what extent the aviation noise disturbs the lessons in a certain classroom is examined by asking the children and teachers. One of the questions to the children was, for example: 'Sometimes it is hard to hear the teacher because of the aircraft noise.' The child had to choose one of four options from 'absolutely not true' to 'absolutely true'."

How were the schools selected?



Schools in the study region. The outermost blue line marks the study region with a continuous sound level in daytime of at least 40 dB (A). Moving inwards, the continuous sound level increases with every contour line by 2.5 dB (A).

Scientists work with random samples. An ecologist takes water samples without having to analyze the whole lake. An educational researcher tests a selection of schoolchildren and extrapolates for the totality. In both cases, where and how the random sample is taken plays a decisive role.

"Matching": Selection of the schools

The aim was clear: to find schools that had different levels of exposure to aviation noise but were otherwise as similar as possible in terms of other factors. As it was not possible to achieve this for all possible influence factors, the scientists had to set priorities.

First they established four aviation noise level classes, to each of which seven or eight primary schools were to be assigned. First the most highly exposed schools in the study area were selected, because these were always going to have to be taken into consideration. Proceeding from there, matching schools were selected from the other noise level classes according to the following criteria:

1. Proportion of children in second grade with a migration background;
2. Proportion of children in second grade with a poor knowledge of German (this proportion could not be taken into account where the schools did not have the data);
3. No very high exposures to other noise sources;
4. Number of children in second grade per school >40;
5. Estimation of the socioeconomic status (Glossary) in the catchment area of the school;
6. Broad spatial distribution of the selected schools in the study area;
7. As far as possible, a positive estimation of the significance of the study by the school.

The following overview of the first two criteria shows that a good balance was achieved between the various aviation noise exposure levels:

	Noise level class*	Proportion of children in second grade with a migration background	Proportion of children in second grade with a poor knowledge of German
4	>55 dB	53 %	19 %
3	50 – 55 dB	53 %	17 %
2	45 – 50 dB	53 %	18 %
1	40 – 45 dB	52 %	15 %

* Equivalent continuous sound level L_{eq} (Glossary)

A total of 29 schools in the four noise level classes were selected in this way. This also includes the two most highly exposed schools in noise level class 4.

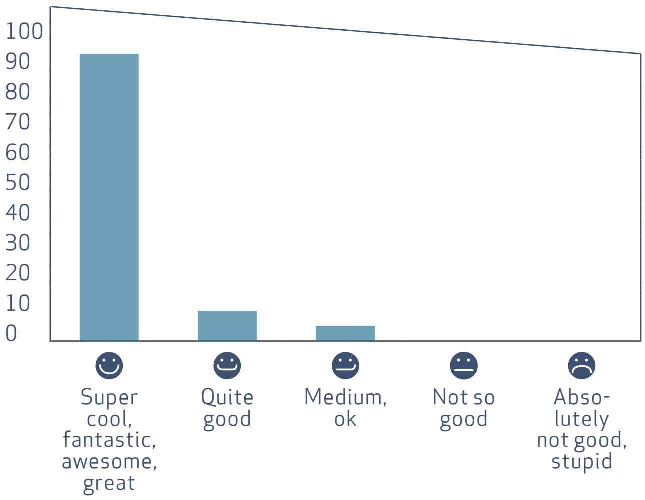
The child study in numbers

- 1,243 children from 85 second-grade classes at 29 schools took part
- 90 % of the parent questionnaires were completed
- Information material for parents was drawn up in nine languages
- The group test took an average of 4 periods (45 minutes each) in each class
- The NORAH study teams spent around 300 periods in the classes
- The survey was carried out between 19.04 and 20.06.2012

The scientists were pleasantly surprised by the great response to the parent questionnaire. 90 % came back completed – well above the average for similar studies. "We have obviously succeeded in convincing the parents about the significance of our study, because many were happy to answer even sensitive questions, for example about their income. I would like to take this opportunity to thank all of those who participated," says Prof. Dr. Maria Klatte, director of the NORAH Child Study.

Super cool, fantastic, awesome, great

And how did the children themselves find the test? 85 % awarded the best grade "super cool, fantastic, awesome, great", 10 % found it "quite good" and just a few "medium, ok".



A predecessor:
The RANCH Study

In 2001 a major study with similar questions to the NORAH child study was conducted at airports in Amsterdam, Madrid and London: the RANCH Study (Road traffic and Aircraft Noise exposure and Children's cognition and Health).

This study established a connection between aviation noise and reading ability: Higher aviation noise exposure was associated with a slight reduction in reading performance. The result was statistically significant (Glossary). Nonetheless, the study is the subject of controversy among scientists, because it also discovered with the same statistical certainty contrary effects in the evaluation of the impact of road traffic noise which could not be satisfactorily explained.

The biggest challenge in studies on the effects of aviation noise on the reading acquisition of children consists in carefully separating the effects of other influence factors from the effect of the aviation noise. In the NORAH child study these influence factors were more precisely scrutinized than in earlier studies in order to be able to attribute any performance differences between children from areas subject to different levels of aviation noise exposure to the aviation noise. The following overview shows the differences between NORAH and the RANCH Study:

	RANCH Study	NORAH	Explanations
Investigation period	2001	2012	
Number of schools	89 (in England, the Netherlands and Spain)	29 in the proximity of Frankfurt Airport	
Age of the school-children	Ca. 9 – 12 years (average: 10.5 years)	Ca. 7 – 10.5 years (average: ca. 8.3 years)	NORAH: younger children because learning to read in German is faster than in English
Class grades	Mixed	Only 2nd grade	NORAH: Children were examined in the same phase of reading acquisition (lower scattering)
Source of the aviation noise data	Estimation of the aviation noise exposure at the school and based on noise maps from periods of 3 to 13 months	Calculation of sound pressure levels at the exact addresses in different time phases (morning at the school, afternoon and night at the home) over a period of 12 months before the tests	

Aviation noise exposure at the school during the day (continuous sound level L_{eq})	30 to 77 dB (A) (7 – 23 hrs)	39 to 59 dB (A) (8 – 14 hrs)	In RANCH the aviation noise exposures were much higher
Aviation noise exposure at the home during the day (continuous sound level L_{eq})	31 to 76 dB (A) (7 – 23 hrs)	36 to 61 dB (A) (6 – 22 hrs)	
Which intellectual abilities and learning achievements were examined?	Reading, attention, short and long-term memory	Reading, attention, short and long-term memory, linguistic precursor abilities of reading such as “phonological awareness” (Glossary)	
Other factors examined	Quality of life, impairment due to aviation noise	Quality of life, impairment due to aviation noise, well-being at school	
How was the socio-economic status (Glossary) of the children estimated?	Various yes/no questions in the parent questionnaire, e.g. “Free lunch at school?”, “Living in your own home?”, “Father unemployed?”	Calculation of the so-called “Scheuch-Winkler Index” (SWI) from information on net income, education and qualification and professional position in the parent questionnaires. The SWI is an index commonly used in social research	
Consideration of different insulation and room acoustics of the schools	Schools with good noise insulation (triple-glazing) were excluded. More than half of the schools had only single-glazing	Noise insulation and room acoustics were examined. Well insulated schools were not excluded because the aim was to examine the real situation in the study region. There were no schools with single-glazing in the random sample	
Conduct of the tests	Without headphones. The sound pressure level during the tests was measured. Any influences of noise during the testing was then “calculated out” during the evaluation	Comprehension tests with headphones to rule out acute noise effects on the test (focus on chronic noise effects). The acute sound pressure level in the classroom was also measured	

NORAH overview

The noise impact study NORAH (Noise-Related Annoyance, Cognition and Health) is so far the most extensive study internationally on the effects of noise from aviation, road and rail traffic on the health and quality of life of the population. Several acclaimed research and technical institutes in the fields of medicine, psychology, social science, acoustics and physics are collaborating in the NORAH research consortium. The investigations are being carried out mainly in the Rhine-Main Region, and to some extent also in the regions around the airports Berlin-Brandenburg, Cologne-Bonn and Stuttgart.

Overview of the NORAH sub-studies

Quality of life study

Over a period of three years, this study is examining how people who live near airports suffer from aviation, road and rail traffic noise, what noise levels they are exposed to, what changes in the noise exposures mean to them, and how they would assess their health and quality of life. A total of around 27,000 people at four airports are taking part in the surveys.

Sleep study

Very early or late flights take place when a lot of people are asleep. How well they manage to do this despite the noise is the subject of the sleep study. Like in a sleep laboratory, the sleep patterns of the study participants are recorded electronically several nights in a row. Parallel to this, a noise level meter direct at the participant's ear measures every noise in the course of the night.

Illness study

Using the health insurance data of 1.5 million insured persons in the Rhine-Main Region, the NORAH team is examining how frequently various illnesses, including heart disease and depression, occur in the region, and which noise the persons concerned were exposed to. Special focus is being placed on the cardiovascular disorders: The scientists are also asking study participants with newly contracted disorders about other risk factors such as excess weight or smoking.

Module Quality of Life
Module Health
Module Development

Blood pressure study

Can our blood pressure also react to exposure to aviation, rail and road traffic noise? What happens when the noise exposure changes? The blood pressure study is pursuing these questions in a monitoring process: Participants from regions with different noise exposures measure their blood pressure every morning and evening over a period of three weeks. More than 1,300 persons have taken part in the first measurement phase, the second phase runs until May 2014.

Child study

Does noise have an effect on the development of children? This is what the scientists want to find out in the child study. Investigations with more than 1,200 2nd grade pupils in the Rhine-Main Region illuminate the connection between noise and intellectual development. Surveys also provide information about the quality of life of the children.

Glossary

We feel it is important to explain the main technical terminology of the NORAH noise impact study in a manner that is comprehensible to laypersons. Terms that are not covered by the glossary will soon be available in the wiki which is currently being prepared.
wiki.umwelthaus.org

Precursor skills
These are skills that are responsible for the acquisition of reading in children. They develop before the child actually begins learning to read. Precursor skills include, for example:

- **Phonological awareness:** refers to an individual's awareness of the phonological structure, or sound structure, of spoken words (see below).
- **Attention:** the ability to concentrate sufficiently on a text.
- **Linguistic short-term memory:** the ability, for example, to remember at the end of a sentence how it started.

Phonological awareness
Awareness that language is made up of different building blocks: sentences, words, syllables, sounds. Phonological awareness also means that a child can detach himself from the meaning of the word "cat" and recognize that it starts with the same letter as "cake".

Confounding
Confounding occurs when a phenomenon depends on two or more conditions that are mutually influencing. If, for example, we want to investigate whether frequent tooth brushing prevents tooth decay in children, it would not be sufficient merely to examine the brushing behaviour and the dental status. This is because children who frequently brush their teeth are most likely actively encouraged to do so by their parents (few of them do it of their own accord). The same parents will probably allow their children fewer sweets. It could be that the healthier teeth are not due to frequent brushing but to a healthier diet. We can only find this out by examining both.

Socioeconomic status
Socioeconomic status is an artificial term that attempts to summarize an individual's economic and social position in society. In the NORAH Study the socioeconomic status was determined with the aid of the so-called "Scheuch-Winkler Index". This is calculated from the three factors: net income, education and qualification and professional position.

Continuous sound level
The equivalent continuous sound level (in short: L_{eq}) is a measure for the average noise exposure over a certain period in which frequency, duration and level of the individual sound events are taken into consideration. The L_{eq} is the basis for the determination of noise protection zones pursuant to the aviation noise act – separated according to day (6 – 22 hrs) and night (22 – 6 hrs). The L_{eq} is stated in decibels (dB).

Significance
In statistics we speak of a significant result if there is only a very low probability (usually less than 5 %) of it being a random effect. The significance can be checked using statistical methods.

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Quality of Life
Health
Development

NORAH
Knowledge No. 4

NORAH noise impact study

Child Study: Impact of aviation noise on children

Results

forum flughafen & region
umwelt- und nachbarschaftshaus

NORAH Knowledge No. 4

NORAH noise impact study

Child Study: Impact of aviation noise on children

Results

"NORAH Knowledge" provides information on the methods and results of the NORAH noise impact study. The aim of this series is to communicate to as many people as possible what exactly NORAH is researching. This is why there is an explanation in the glossary at the end for all terms marked "▤ Glossary". If you would like to receive further issues of "NORAH Knowledge", please use the enclosed order form.

The NORAH Study examines the long term effects of traffic noise (▤ Glossary) on health, quality of life and childhood development in the Rhine-Main Region. The initiator of the study is the Airport and Region Forum (AFR). The scientists were accompanied from the start by an external Scientific Advisory Board for Quality Assurance (WBQ). This is what distinguishes NORAH from similar, predecessor studies. The study addresses some of the most topical issues currently being dealt with by international noise impact research.
It also covers a wider range of investigation aspects than previous studies. In order to find out more about how human beings respond to traffic noise, the NORAH scientists also looked at the medical histories of more than one million people, and reconstructed the noise exposure over the last 18 years at 900,000 addresses in the Rhine-Main Region.
A total of five sub-studies form the core of the NORAH Study. Each one builds on the current international state of research, and attempts to understand more precisely how traffic noise affects people. In this edition of NORAH Knowledge we present the results of the Child Study, one of the five sub-studies. The Child Study is an advance publication; the main part of the study will be published in autumn 2015.
NORAH Knowledge No. 1 contains detailed information on the methods and tasks of the Child Study.

NORAH ("Noise Related Annoyance, Cognition, and Health") is the most extensive investigation into the effects of exposure to aviation, road and rail noise that has ever been carried out in Germany. It is being conducted by nine independent scientific institutes from all over Germany. The client is the Umwelt- und Nachbarschaftshaus, a subsidiary of the Land of Hessen and part of the Frankfurt Airport and Region Forum. Alongside the land of Hessen, communities, Fraport AG and Lufthansa were also involved in the financing.

Contents

Further information on the NORAH Study can be found on the Internet at **www.laermstudie.de**.

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CENTRAL RESULTS OF THE CHILD STUDY – SUMMARY

What impact does aviation noise have on childhood development and quality of life? The NORAH Child Study attempted to find an answer to this question. To do this, the scientists on the NORAH team conducted tests, surveys and measurements at 29 schools, in 85 school classes, with 1,243 children, 1,185 parents and teachers in the Rhine-Main Region. The study focuses on learning to read, the health and wellbeing at school of the children as well as the noise exposure when learning at home and in school. It thus builds directly on earlier studies at other locations and attempts to answer some as yet open questions.

Aviation noise reduces reading performance

In areas with high exposure to aviation noise, primary school children learn to read more slowly than children in quiet areas. In the second grade children examined, an increase of the continuous sound level (Glossary) by ten decibels (Glossary) delayed acquisition of reading skills by one month. The connection is linear: the higher the exposure, the greater the negative effect on development. NORAH was unable to verify direct effects of aviation noise on precursor skills for reading acquisition such as phonological awareness or listening comprehension.
More on this on page 6.

Quality of life in terms of school and health slightly affected

The overall quality of life of the children surveyed in the Rhine-Main Region is high – most of the second-grade children feel very well; they are healthy and enjoy going to school. Children in areas with high exposure to noise do not feel quite as well as children in quieter areas. In addition to this, parents surveyed in areas with relatively high aviation noise exposure stated more frequently that their child was taking prescribed medication or had been diagnosed with a speech or language disorder. The children concerned were no different, however, to the other children in terms of their ability to learn to read.
For more on this see page 8.

Aviation noise disturbs lessons

Teachers from areas with relatively high aviation noise exposure reported unanimously that the noise causes considerable disturbances to lessons. Classes are interrupted in various ways by aviation, often distracting the children's attention. More than one third of the children from these schools are sometimes unable to hear the teacher properly due to aviation noise.
For more on this see page 12.

WHAT DID THE CHILD STUDY EXAMINE?

If children are permanently exposed to aviation noise, this can have a negative impact on their intellectual development and their learning performance. Various previous studies have come to this conclusion. In particular, the ability to read appeared to suffer under the influence of aviation noise. However, these older studies did not take into account several confounding factors (Glossary) that might have influenced the result. Also, they were carried out in areas with very different and considerably higher noise exposure.

The greatest difficulty in the investigation of learning performance under the influence of aviation noise: we know from numerous educational studies that learning performance is determined by a wide range of different factors. Among other things, the socioeconomic status (Glossary), for example the educational standard and the income of the parents, as well as their origins, can have a clear statistical influence on the learning performance of the children. The scientists have to take all of these factors into account and filter them out if they want to find out what impact aviation noise has on learning to read.

The scientists in the Child Study tried to answer the following questions:

- Is it possible to identify a negative impact of aviation noise on intellectual abilities such as reading acquisition, linguistic skills, attention or memory of children in the Rhine-Main Region?
- How exactly does aviation noise at school affect lessons?
- To what extent does aviation noise affect the wellbeing of the children at home and at school?
- How large is the influence of aviation noise relative to other factors?

The selection of schools and children

The scientists first divided up the Rhine-Main Region into different "noise level classes", i.e. into regions where a certain continuous noise level (Glossary) prevails during the day. Schools in all four areas were asked to participate. A total of 1,243 second-grade boys and girls took part in the investigation, around the same number in each sound level class. The schools with the lowest level of aviation noise exposure had a continuous noise level during the day of 39 decibels (Glossary). In the schools with the highest level of exposure, the continuous noise level was 59 decibels. At the time of the investigation, there were no primary schools in the Rhine-Main Region with higher exposure to aviation noise than the primary schools in the highest sound level class.

In order to investigate how well the children can read, the scientists used standardized tests which are also used in other learning studies. The study also wanted to examine the thesis that exposure of children to aviation noise has an effect on the precursor skills for reading acquisition which normally develop at a pre-school age. These skills – for example listening comprehension – are important for learning to read later. The NORAH team also asked the children, their parents and the teachers about the wellbeing and the quality of life of the children and about the extent of the negative effect they feel aviation noise has on them.

1,243 boys and girls in second grade, continuous noise level during the day between 39 and 59 dB (A)

Kirstin Bergström

Individual noise calculations

In order to identify a connection between the performance of the children and the noise exposure, it is important to know as precisely as possible which noise level each individual child is exposed to at home and at school. This is why the NORAH acoustics team carried out extensive noise calculations for the Child Study. This was based on the radar records of all flight movements in the Rhine-Main Region for the last 15 years. These were used to calculate the individual aviation noise exposures in the twelve months before the data collection for all the residential and school addresses of the children in anonymized form. In their evaluations the NORAH scientists also took into account the existing sound insulation and the reverberation times in the classrooms. The acoustic team also calculated the noise exposure due to rail and road noise where the children live and at school.

The current state of research

One of the most important studies carried out before NORAH on the impact of aviation noise on children is the so-called RANCH Study. In 2001 this study investigated similar questions at the airports of Amsterdam, Madrid and London, and discovered a connection between aviation noise and reading performance. Some of the results of the RANCH Study were contradictory, however. Also, they cannot be fully applied to the current situation in Germany because the noise levels in the RANCH Study were much higher. One important assumption of RANCH and other studies is that if aviation noise has any impact on school performance, then most likely on learning to read, because this has to do with language processing. This is why both RANCH and NORAH focussed precisely on this aspect.

Overview: What did the Child Study investigate and how?

What was investigated?	Method
◢ Aviation, rail and road noise exposure at school and at home	Data calculated by the NORAH acoustics team
◢ Building and room acoustics of the classrooms	Estimation methods for determination of the reverberation time and the noise insulation
Reading ability and precursor skills ◢ Reading skills ◢ Short and long-term memory for linguistic information ◢ Phonological awareness ◢ Speech perception ◢ Attention ◢ Non-language skills	Standardized group tests in the class
Quality of life and environment ◢ Wellbeing at school and at home, classroom atmosphere, socioeconomic status	Child survey, parent questionnaire, teacher questionnaire
Noise exposure at school and at home	Child survey, parent questionnaire, teacher questionnaire

Kirstin Bergström

The scientists used standardized tests to examine the reading ability and the precursor skills of the second-grade children.

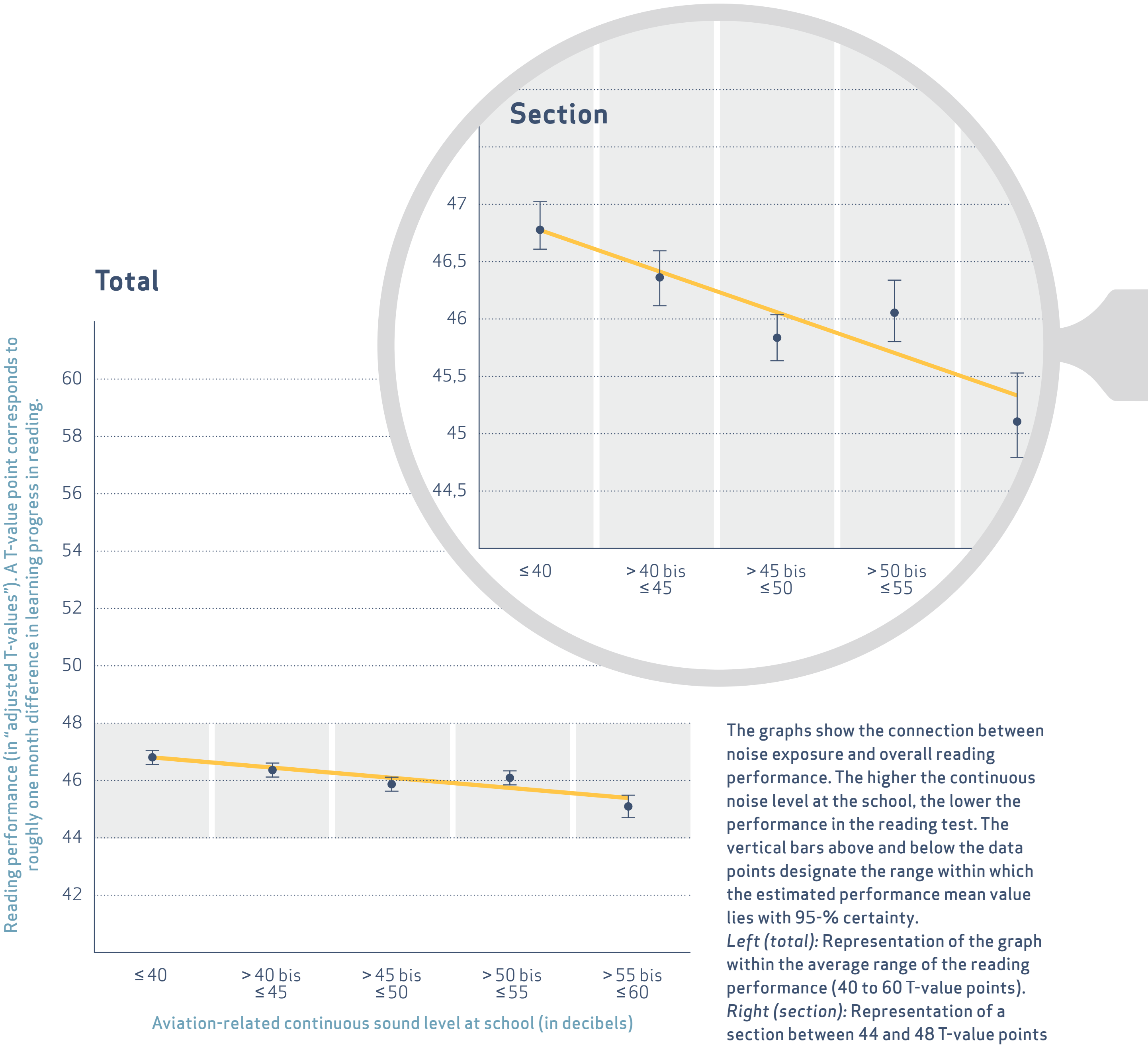
Twin Design/Shutterstock

THE EFFECTS OF AVIATION NOISE ON LEARNING TO READ

Aviation noise has an effect on the reading performance of children who are in the learning-to-read phase. The connection is linear: the higher the exposure, the greater the negative effect on development. In the second-grade children examined by the study, an increase of the continuous noise level (Glossary) by ten decibels (Glossary) delayed learning to read by one month. An increase of the continuous noise level by 20 decibels led on average to a delay of two months. For the investigation area of the NORAH study, this means that the delay is around two months in the areas with the highest exposure to aviation noise.

What else has an influence on learning to read?

The NORAH Study not only investigated the effects of aviation noise on learning to read but also other factors whose influence on learning is known – for example German-language skills or the number of children's books in the home. This was the only way to determine exactly the extent of the effect of aviation noise on learning to read. With these data the scientists were also able to show that some of the factors investigated in the study had a greater impact than aviation noise on learning to read. For example, children who have a lot of books were four months ahead in reading texts compared with children who do not own their own books. It is not possible to make a direct comparison here, however, because parents can decide themselves how much help they want to give their children in learning to read. They do not have any influence, however, on the aviation noise.



The graphs show the connection between noise exposure and overall reading performance. The higher the continuous noise level at the school, the lower the performance in the reading test. The vertical bars above and below the data points designate the range within which the estimated performance mean value lies with 95-% certainty.
Left (total): Representation of the graph within the average range of the reading performance (40 to 60 T-value points).
Right (section): Representation of a section between 44 and 48 T-value points to illustrate the effect. A T-value point corresponds to roughly one month difference in learning progress.

The NORAH scientists were unable to establish any statistically significant connection (Glossary "Significance") between aviation noise and learning to read in children with a migration background. This result should not, however, lead to any hasty conclusions. The authors of the study suspect that it is due to a statistical effect: it is possible that there are so many factors confounded in this sub-group that it was no longer possible to reliably identify effects of aviation noise.

The result certainly does not mean that children with a migration background are insensitive to aviation noise.

If we look at only the children without a migration background, an increase of the continuous noise level by ten decibels led to a delay of 1.5 months in learning to read. This means that the difference between the children most exposed and the children least exposed in the investigation area was three months.

Still unknown: the reasons for the reading deficit

Up to now, researchers have not been able to explain exactly how aviation noise impairs the ability to learn to read. Some scientists suspect that the noise exposure has an effect on the development of the so-called precursor skills – skills that children acquire at a preschool age. This includes for example "phonological awareness", which allows us to identify the sounds in words, and good listening comprehension. NORAH Study examined this thesis. The result: the scientists were unable to identify any link between aviation noise and the precursor skills.

THE QUALITY OF LIFE OF THE CHILDREN IN THE RHINE-MAIN REGION

The NORAH-scientists were not only interested in the reading performances, but also in the general health and quality of life of the children. The questions they asked the children and their parents concerned, for example, the sleep quality or the mental and physical wellbeing. The results show that the quality of life of the children in the investigation area is generally very high. The children and parents with relatively high exposure to aviation noise, however, assessed the health and quality of life of the children as slightly poorer than those with low exposure. Although the difference is small, it is statistically significant (Glossary "Significance"): with an increase of the aviation noise by ten decibels, the quality of life fell on the three to five-point assessment scales by an average of 0.1 scale points.

No effects verified on precursor skills

Noun fonts/ Eugen Traeger Verlag

In the so-called picture test, the children were asked to put a line through everything that begins with B, and mark all of the other pictures with a dot. This allowed the NORAH scientists to examine how quickly children can call up words from their memory and make a decision on the sound of the first letter (B or not B).

The quality of life from the point of view of the children

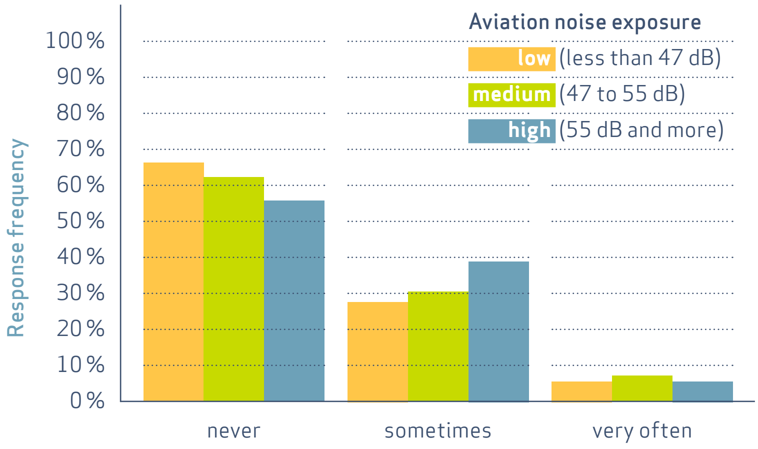
In order to find out how the children assess their physical and mental quality of life, the scientists asked them to answer various questions relating to the last week. Among other things, children were asked whether they had suffered from headaches or tummy problems in this time, whether they slept well, and whether they had been bored. To answer the questions they could choose from "never", "sometimes", or "very often". It was shown that there was a statistically significant effect of the aviation noise on the responses.

In the group of children with the lowest level of noise exposure, 67 percent stated that they never had headaches or tummy aches. In the group of children with the highest level of noise exposure only 56 percent said this. The scientists were able to statistically rule out any other differences between the groups – e.g. different socioeconomic status (Glossary) – that might have had an influence on the children's responses.

The results were similar when the children were asked whether they had slept well in the past week. In the group with the highest level of noise exposure, 20 percent of the children stated that they "never" slept well – compared with 15 percent of the children with only low exposure to aviation noise. The parents, however, gave a different assessment of the sleep quality of their children: their responses to the question about their children's sleep do not indicate any connection with aviation noise.

To assess their mental wellbeing, the children were asked, among other thing, whether they had been bored in the past week. The result: the more aviation noise, the more likely the children were to state that they had been bored in the last week. An increase in the aviation noise by ten decibels (Glossary) led to a deterioration of 0.14 on a three-point scale. Only around 40 percent of the children with high noise exposure stated that they were never bored, compared with 53 percent of the children in areas with low aviation noise exposure.

"In the last week I had headaches or tummy ache."



Responses of the children to the statement "In the last week I had headaches or tummy ache" in the groups with low, medium and high aviation noise exposure. Children in the areas with high exposure were less likely to state that they had "never" suffered from headaches or tummy ache.

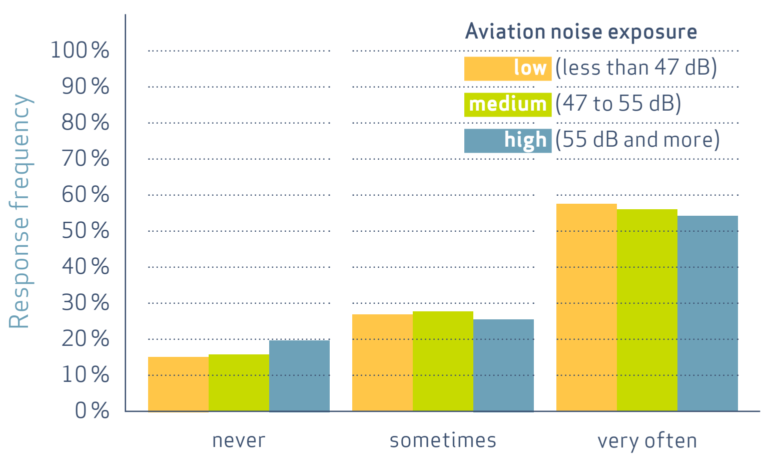
More medication and speech or language disorders

A total of 1,185 parents answered the scientists' questions about the health and the wellbeing of their children. They also provided information on the disorders which their children suffer and about absence times from school. In most of these answers the scientists were unable to identify any differences that could be attributed aviation noise.

For two questions, however, there proved to be a connection between the parents' answers and the aviation noise exposure. Ten percent of the parents in areas with relatively high noise exposure state that their children are currently taking prescribed medication. In the residential areas with medium exposure it was only four percent, and in the regions with low exposure just under six percent.

In areas with relatively high noise exposure, 14 percent answered "yes" to the question: "Has a doctor ever diagnosed a language or speech disorder in your child?" In areas with low noise exposure, only 10 percent gave this answer, in the residential areas with medium exposure it was 8 percent. These results are statistically unequivocal. It was not asked, however, what the exact nature of the disorder was. By comparison: in Germany as a whole the frequency of speech or language disorders in children ranges, depending on the diagnosis criterion, between 2 and 15 percent. The connection should thus be made the subject of further investigation. It is important to know that the children described as being diagnosed by their parents did not differ in their reading performance to the rest of the group.

"In the last week I slept well."



Responses of the children to the statement "In the last week I slept well" in the groups with low, medium and high aviation noise exposure. Children in the areas with high exposure stated somewhat more frequently that they were "never" able to sleep well in the last week.

Tatyana Vyc/Shutterstock

How happy are the children at school in the Rhine-Main Region?

Some studies show that a high level of noise exposure at school can also influence the attitudes of the children to school and learning. This is why the NORAH Study also looked at the "school-related quality of life". For this purpose the children responded to statements such as for example "I am happy learning new things" and "I feel well at school". The result showed a statistically significant (Glossary "Significance"), but very low influence of aviation noise on the responses. Children exposed to relatively high levels of aviation noise are slightly less positive towards learning and school. The difference amounts to just one eighth of a scale point on a four-point scale.

The parents and teachers were also asked about the school satisfaction of the children and about the atmosphere in the classroom. This did not show any significant connection with aviation noise.

DOES AVIATION NOISE DISTURB LESSONS?

The degree of annoyance caused by noise is subjective: the same sound can bother one person more than it does another. This is why it is not possible to deduce from the noise level alone how burdened people feel by aviation noise. In order to find this out within the framework of the Child Study, the scientists asked parents, children and teachers whether and, if yes, to what extent, the aviation noise disturbed children when learning.

Noise exposure from the point of view of the children

In order to find out whether the children felt disturbed by aviation noise, the scientists asked them several questions. For example, the NORAH team asked the second-grade pupils to assess the statement "The noise of the planes disturbs my lessons." They could choose from four possible answers: "strongly disagree", "partly disagree", "partly agree" and "strongly agree". In the group of children whose schools were exposed to a relatively high level of aviation noise, 27 percent stated that the noise disturbs their lessons. Only 7 percent of the children in the group with low noise exposures gave the same answer. Communication in the classroom also suffers from aviation noise: 38 percent of the children – i.e. more than one third – at the schools with high exposure stated that they were sometimes unable to hear the teacher properly due to aviation noise.

The point of view of the teachers

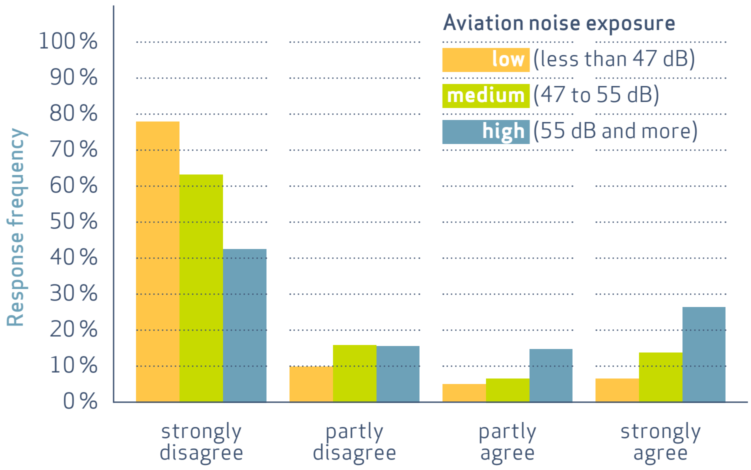
From the teachers the NORAH scientists wanted to know how aviation noise affects classes – for example, how often it leads to interruption of lessons. The teachers in the areas with relatively high aviation noise exposure reported unanimously that the noise causes a considerable disturbance of lessons: 24 percent stated here that they have to interrupt lessons due to aviation noise "very often", a further 29 percent answered with "often". In the areas with low noise exposure, nobody chose the answers "very often" or "often" or "sometimes".

Questions regarding the teaching process showed a connection with aviation noise exposure: 52 percent of the teachers in the areas with high exposure said that the children were "often" or "very often" distracted from their lessons due to aviation noise, 57 percent said they always keep the windows closed even when the weather is warm. 76 percent stated that aviation noise could be heard "often" or "very often" even with the windows closed. Outdoor activities at schools with high aviation noise exposure are also less common: 38 percent of the teachers in these areas agreed fully or partly with the statement "Due to aviation noise I am less likely to undertake outdoor activities with the class" – compared with three percent at the schools with medium exposure. Nobody chose these answer options at the schools with low exposure.

Aircraft and other noise sources

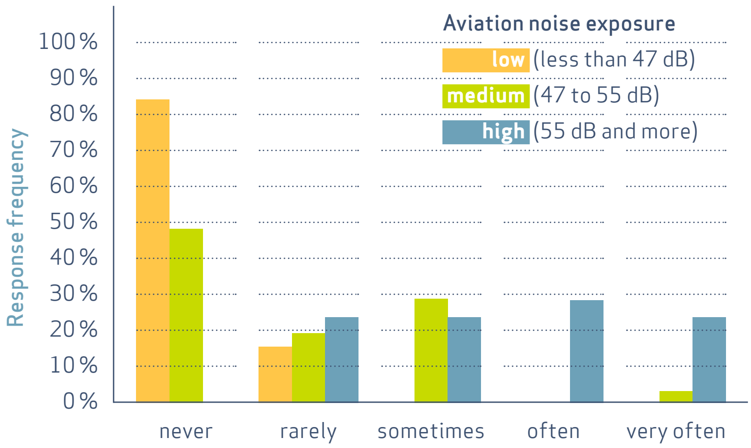
Even where there is no aviation noise, schools are not quiet places: noise penetrates into the classroom from the playground and from the other classrooms. In order to estimate which role aviation noise plays compared with other noise sources, the scientists asked the teachers to estimate which types of noise their classes are exposed to and to what extent. For each source of noise the teachers estimated the degree of class disturbance on a five-point scale, where 1 stood for "no disturbance" and 5 for a "very high disturbance". The result: teachers perceive noise from the playground or from the other classrooms as disturbances of their class. However, at schools with relatively high aviation noise exposure, from the point of view of the teachers the greatest disturbance by far is aviation noise: On the five-point scale the answers for this type of noise reach an average value of 4.5. In order to make the clearest possible statements about the impact of aviation noise, the NORAH Study did not include any schools with very high exposure to road or rail traffic noise. This is why the teachers assessed the disturbance of classes due to these types of noise as relatively low. This, however, cannot be generalized. In the Rhine-Main Region there are also schools with very high exposure to road or rail noise.

"The noise of the planes disturbs my lessons."



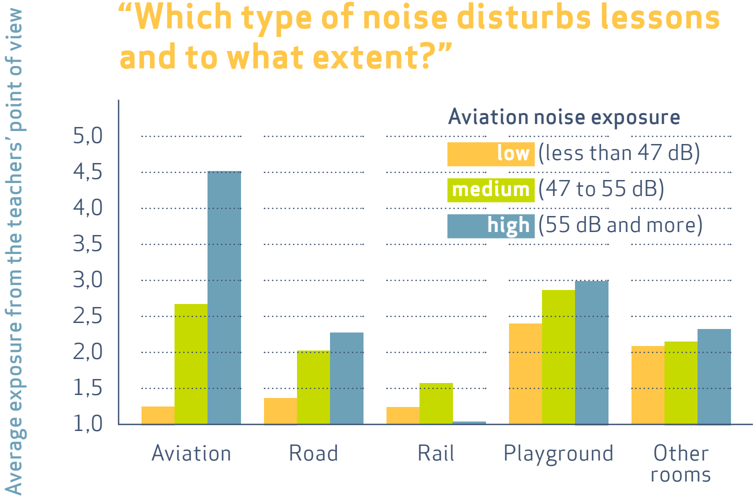
Responses of the children to the statement "The noise of the planes disturbs my lessons" in the groups with low, medium and high aviation noise exposure.

"Due to the aviation noise I have to interrupt the lesson/my speech for a moment."



Responses of the teachers to the statement "Due to the aviation noise I have to interrupt the lesson/my speech for a moment" in the groups with low, medium and high aviation noise exposure at school. Almost one quarter of teachers in high-exposure areas state that they have to interrupt lessons due to aviation noise "very often".

"Which type of noise disturbs lessons and to what extent?"



Teacher assessment of the disturbance of lessons due to various noise sources at schools with low, medium and high exposure to aviation noise (mean values: 1 = no burden, 5 = very high burden). According to the teachers at schools with high exposure to aviation noise, this is more disruptive of lessons than noise from the playground or other rooms.

INTERVIEW WITH THE STUDY DIRECTOR PROF. MARIA KLATTE

Thomas Schinauer

Director of the Child Study: Psychologist Prof. Dr. Maria Klatte from the Technical University of Kaiserslautern

Prof. Dr. Maria Klatte is the director of the Child Study. In an interview with “NORAH Knowledge” the psychologist from the Technical University of Kaiserslautern talks about her assessment of the results.

Did any of the results of the NORAH Child Study surprise you?

There is already a whole range of studies on this issue. The children in those studies, however, were subject to much higher levels of exposure to aviation noise, spectacularly higher levels. Nonetheless, only very minor effects could be identified. With this pre-knowledge we were not sure at the start of the study whether we would even be able to detect any effects on the reading performance of the children. We had not expected that statistically significant effects could be verified despite the low levels of exposure.

Were the other results as you expected them to be?

No, for example the increased frequency of medically diagnosed speech and language disorders and intake of medication: that is a result of the parent survey. We did not expect that this would show up so clearly. This is something we really need to pursue further to find out what exactly is behind it.

In your opinion, how serious are these speech and language disorders?

We do not know exactly which type of disorders led to the differences shown in our study. But we did examine whether the children who, according to their parents, had a speech or language disorder differ from the other children in terms of their reading performance. This is not the case. This is why we do not believe that we are looking at very serious disorders here. But we do not know exactly, and this is why there have to be follow-up investigations.

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If parents hear about your study and start asking themselves whether their child is worse off than children in quieter areas: what would you tell them?

We asked the parents and the children about the physical and mental wellbeing of the children. This was represented as very positive by both groups. Children exposed to aviation noise do not feel bad, but they do feel a tiny bit less good. Other factors certainly have a greater influence on the wellbeing of the children. Nonetheless, the effect is statistically significant. And we cannot tell how that will develop in the long term if the children have to live and learn under the influence of aviation noise.

You identified a delay in learning to read of up to two months in second-grade pupils. Does this mean that children living near an airport are less likely to complete secondary school or generally have fewer chances?

It is not possible to answer that with any certainty because we do not know how the relatively small difference in the second-grade pupils will turn out in the long term. First we have to say that the identified statistical effect on the reading performance is small. There are other influencing factors that are far more important. But we do not know how that will develop. We also surveyed the school directors of the participating schools. We asked them which proportion of the children in their school go on to secondary school from primary. We did not find any difference here: in the schools exposed to high levels of aviation noise that participated in the study, on average the same proportion of children went on to secondary school as in the schools with lower exposure.

You also spoke to teachers ...

Yes, the clarity of the results of the teacher survey were a surprise. We know that interruptions of the teaching flow are very unfavourable for children at this age. Up to now, research has focused mainly on reading performance. But these frequent interruptions can, of course, also have an unfavourable effect on other subjects.

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OUTLOOK: WHAT HAPPENS AFTER THE CHILD STUDY?

The Child Study within the framework of NORAH delivered several important insights which will help us to understand how aviation noise affects the intellectual development and the quality of life of children. We now know, for example, with very high probability, that aviation noise impairs learning to read. But the Child Study also threw up some new questions. Further studies are necessary to provide the answers to these.

One of the unanswered questions is: in what way exactly does aviation noise affect learning to read? The NORAH Study was unable to confirm that the important precursor skills for reading acquisition develop less well under the influence of aviation noise. This is why scientists now have to postulate new theories and examine them in suitable studies.

Another question that has newly arisen within the framework of NORAH concerns the health and quality of life of the children. Parents from the residential areas with high exposure to aviation noise stated more frequently that their child was taking prescribed medication at the time of the survey or had been diagnosed as having a speech or language disorder. The Child Study did not, however, investigate which medication was being taken or whether certain language or speech disorders are particularly frequent. These questions – which have never been raised by any previous study – must also be made the subject of further studies.

We also have to answer the question as to the further development of the children concerned – in particular if they continue to be exposed to aviation noise. Will the effect of the aviation noise get worse, will it remain the same, will it become less or disappear altogether? The NORAH Study cannot make any statement on this because it has not followed the progress of the children concerned. A so-called longitudinal study which would register the performance of the same children at various points of time in the future – for example in a few years – could provide answers to these questions.

Glossary

Further explanations can be found in the glossary at **www.laermstudie.de**.

Continuous sound level

The equivalent continuous sound level (in short: L_{pAeq}) is a measure for the average noise exposure over a certain period in which frequency, duration and level of the individual sound events are taken into account. The L_{pAeq} is the basis for the determination of noise protection zones pursuant to the aviation noise act – separated according to day (6 – 22 hrs) and night (22 – 6 hrs). The L_{pAeq} is stated in decibels (dB).

Decibel

Decibel (dB) is a physical unit of measurement used, among other things, for the sound pressure level. The NORAH Study uses the so-called A-weighted sound pressure level. This means that when the sound event was measured, frequencies were weighted with a filter designed to replicate human hearing. The "A" in the expression L_{pAeq} is a reference to the use of the A-weighting.

Significance

In statistics we speak of a significant result if there is only a very low probability (usually less than 5 %) of it being a random effect. The significance can be checked using statistical methods.

Socioeconomic status

Socioeconomic status is an artificial term that attempts to summarize an individual's economic and social position in society. In the NORAH Study the socioeconomic status was determined with the aid of the so-called "Scheuch-Winkler Index". This is calculated from the three factors: net income, education and qualification and professional position.

Confounding

Confounding occurs when a phenomenon depends on two or more conditions that are mutually influencing. If, for example, we want to investigate whether frequent tooth brushing prevents tooth decay in children, it would not be sufficient merely to examine the brushing behaviour and the dental status. This is because children who frequently brush their teeth are most likely actively encouraged to do so by their parents (few of them do it of their own accord). The same parents will probably allow their children fewer sweets. It could be that the healthier teeth are not due to frequent brushing but to a healthier diet. We can only find this out by examining both.

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NORAH Noise Impact Study

Study on Health Risks

Results

forum flughafen & region
umwelt- und nachbarschaftshaus

NORAH

Knowledge No. 12

NORAH Noise Impact Study

Study on Health Risks

Results

“NORAH Knowledge” provides information on the methods and results of the NORAH noise impact study. The aim of this series is to communicate to as many people as possible what exactly NORAH researched. This is why there is an explanation in the glossary at the end for all terms marked “glossary”.

If you would like to receive further issues of “NORAH Knowledge”, please use the enclosed order form.

The NORAH Study investigated the effects of aircraft, road and rail traffic noise on humans.

von Aichberger

NORAH ("Noise-Related Annoyance, Cognition, and Health") is the most extensive investigation into the effects of exposure to aircraft, road and rail traffic noise that has ever been carried out in Germany. It was conducted by nine independent scientific institutes from all over Germany. The client was the Umwelt- und Nachbarschaftshaus, a subsidiary of the state of Hessen and part of the "Forum Flughafen und Region". Alongside the state of Hessen, communities, Fraport AG and Lufthansa were also involved in the financing.

The NORAH Study examined the long-term effects of traffic noise on health, quality of life and early childhood development in the Rhine-Main Region. The initiator of the study was the Airport and Region Forum (ARF). The scientists were accompanied from the start by an external Scientific Advisory Board for Quality Assurance (WBQ). This is what distinguishes NORAH from similar, predecessor studies. The study addressed some of the most topical important issues currently being dealt with by international noise impact research. It also covered a wider range of investigation aspects than previous studies. In order to find out more about how human beings respond to traffic noise, the NORAH scientists also looked at the medical histories of more than one million people, and reconstructed the noise exposure at around 900,000 addresses in the Rhine-Main Region.

A total of five sub-studies form the core of the NORAH Study, each one built on the current international state of research. In addition to this, extremely complex and innovative techniques were used to calculate acoustic exposure. In this edition of "NORAH Knowledge" we present the results of the Study on Health Risks, one of the five sub-studies.

Contents

Further information on the NORAH Study is available on the Internet at **www.laermstudie.de**. There you can also subscribe to the newsletter "NORAH Brief".

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OVERVIEW OF THE STUDY ON HEALTH RISKS

The Study on Health Risks focuses on five diseases: heart attack, stroke, heart failure (also called cardiac insufficiency) including hypertensive heart disease without heart failure, depression and breast cancer. All five diseases are wide-spread in Germany. They have one more thing in common: past studies suggest that all of these diseases occur with above-average frequency in persons who are exposed to a lot of traffic noise in their everyday lives.

The Study on Health Risks dealt with this suspicion. The scientists evaluated the health insurance data of about one million persons in the Rhine-Main Area. For this, the NORAH team cooperated with three large health insurances in the Rhine-Main Area. In parallel, the NORAH acousticians calculated the aircraft, road and rail traffic noise at all addresses in the Rhine-Main Area, partially even back to 1996. A special data privacy procedure ensured anonymity of the study participants. In the end, the NORAH team knew how many insured persons suffered from one of the five diseases, when and how much noise the place of residence of this person was subject to, but not where these persons lived or what their names were. Several thousand persons additionally participated in a more detailed survey. This enabled the scientists to collect further insights on the effects of noise among persons suffering from cardiac insufficiency.

The cardiovascular risk is increased by exposure to traffic noise

The NORAH study proves that traffic noise can increase the risk of developing heart attack, stroke or cardiac insufficiency. Only taking into consideration the long-term energy equivalent sound level (glossary), the risk of cardiac insufficiency was most strongly associated with railway noise, followed by road and aircraft noise. There were indications that the duration of the noise exposure was also relevant to cardiovascular risk. The scientists were also able to find a statistically significant (glossary) connection between strokes and all three examined traffic noise types - i.e. aircraft, road and railway noise. However, for aviation noise, the stroke risk tended to decrease as the long-term energy equivalent sound level increased. A statistically significant increase in stroke risk due to aircraft noise was only shown when considering the maximum aircraft sound level at night. For those who had a heart attack, there was a connection to road and railway sound. For those insured who died during the period of examination, there was a connection to aircraft sound. Depending on disease, noise type and group examined, the risk increases by up to 3.9 percent per ten dB (glossary) of increase in traffic noise.

Depression: traffic noise increases the risk of disease

All three types of traffic noise can contribute to developing depression. The scientists were able to calculate that the risk for a depressive episode increases on average by 8.9 percent when the aircraft noise stress increases by ten dB. For road noise, the risk rose by 4.1 percent per ten dB increase, for railway noise by 3.9 percent. However, these averages only partially reflect the study results. For aircraft and railway noise, the NORAH team found that the risk seems to drop again at very high sound levels. One possible explanation for this would be that people who tend to develop depression often move to calmer areas.

Breast cancer: further research required

A possible influence of traffic noise on the development of breast cancer was only suggested by three studies before NORAH. There was less evidence from the beginning for this association than for cardiovascular diseases, for example. The NORAH Study was unable to confirm that road or railway noise may contribute to the development of breast cancer. For aircraft noise, however, the scientists found a small connection: in the group of women where the long-term energy equivalent sound level between 11 p.m. and 5 a.m. was above 55 dB, there were more cases of breast cancer than expected. Further research on this subject is needed. Indisputable conclusions are not possible yet.

The Study on Health Risks focuses on five diseases: heart attack, stroke, heart failure, depression and breast cancer.

THE QUESTIONS AND METHODS OF THE STUDY ON HEALTH RISKS

The Study on Health Risks wanted to find out whether traffic noise increased the likelihood of developing heart attack, stroke, heart failure or hypertensive heart disease, depression or breast cancer. To answer this question, epidemiologist (glossary) and specialist for occupational medicine Prof. Dr med. Andreas Seidler and his team of scientists from the TU Dresden decided to use a case-control study. This form of study compares people suffering from a specific disease ("cases") to those that do not ("control persons"). It examines whether specific factors – in the case of NORAH, traffic noise – occur more frequently in the group of patients. To come to an indicative result, case-control studies sometimes need to include several thousand persons.

Health data from three statutory health insurers

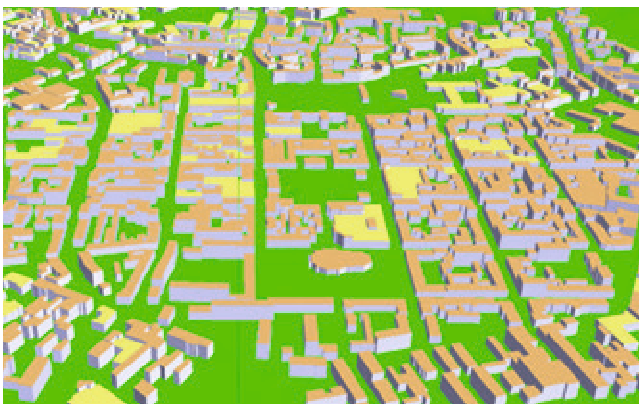
For the Study on Health Risks, three large health insurers from the Rhine-Main Area provided the scientists with the "pseudonymised" (glossary) data of approx. one million insured persons. Using complex search queries, the NORAH team was able to filter out those persons who suffered from one of the five diseases between 2005 and 2010. Persons were to be included as "cases" when doctors in the hospital or a practice diagnosed the disease for the first time. Since most of the examined diseases only occur more frequently in the second half of life, the scientists included only insured persons older than 40.

Individual noise calculations

To answer the research questions, the NORAH team also needed to know how much road, aircraft and railway noise each of the insured persons were exposed to at home. Therefore, the study acousticians calculated the noise load for approx. 900,000 addresses within the examination area – not only for the present, but retroactively to 1996. This way, the noise exposure over several years could be reconstructed for insured persons who lived in the area under examination during this time period and whose past addresses were known to the health insurance.

The NORAH acousticians based their aircraft noise calculations on radar recordings of all aircraft movements in the Rhine-Main Area – this data was provided by the German Air Traffic Services. States and municipalities provided the scientists with information on the road traffic in the examined area. The Deutsche Bahn and Germany's Federal Railway Office (EBA) provided data on rail movements in the Rhine-Main Area. The acousticians also used a three-dimensional terrain model for their calculations to determine how noise from cars and trains spreads. This information could finally be used to calculate when and how much noise was audible at each address in the area under examination.

Terrain models show where there are hills, valleys and buildings. The acoustic team used them to calculate how the railway and road traffic noise spread in the examined area.



Möhler + Partner AG

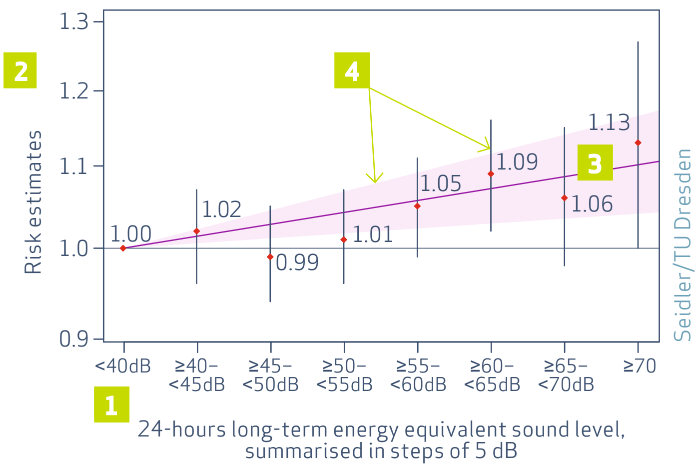
More precise results from an in-depth survey

The health insurance data provided the NORAH team with lots of information on the diseases of the insured persons. Since cardiovascular diseases, in particular, are known to have several other risk factors – e.g. smoking or being overweight – the scientists asked some insured persons to participate in an in-depth survey. They thus received additional information on the lifestyle and living situation of several thousand persons. With this information, the NORAH team was able to examine whether consideration of further risk factors changed the traffic noise results among persons suffering from cardiac insufficiency.

A reading aid for this issue of NORAH Wissen

The Study on Health Risks examines whether the risk of developing one of the five examined diseases increases when exposed to more traffic noise. The scientists present the results of their research in exposure-effect curves (glossary). Since you will find many of these curves on the following pages, we provide a reading aid here:

Heart attack and road noise



1

Long-term energy equivalent sound level

This axis shows the long-term energy equivalent sound level (glossary). The noise increases from the left to the right. For some calculations, the scientists also used "Sound level classes". If, for example, the long-term energy equivalent sound level at the address of an insured person was at 63.7 dB (glossary), their health data was included in the calculation for the sound level class "→ 60 dB – < 65 dB".

2

Risk estimates

Risk estimates indicate how high the "relative illness risk" is. 1 corresponds to the "basic risk" of a person not subject to traffic noise. If the value is higher, this suggests that noise at this degree may contribute to the disease. Additional calculations must show whether an increased or reduced relative risk is statistically significant (glossary) and thus with a high probability not due to chance.

3

Exposure-effect-curve

The exposure-effect-curve shows how the health risk changes with increasing noise. In this example, the risk increases by 2.8 percent per ten dB. Additional calculations show whether this increase is statistically significant.

4

Confidence intervals

The confidence interval is a statistically calculated trust range above or below the risk estimates. The smaller the confidence interval, the more reliable and indicative the risk estimates. It is usual to apply a 95 percent confidence interval. Simplified, this means that the "actual" risk is within this range with a probability of 95%. The figures show the 95 percent confidence intervals of the individual risk estimates (black vertical lines) as well as the 95 percent confidence interval above and below the exposure-effect curve (pink area).

TRAFFIC NOISE INCREASES HEART ATTACK RISK

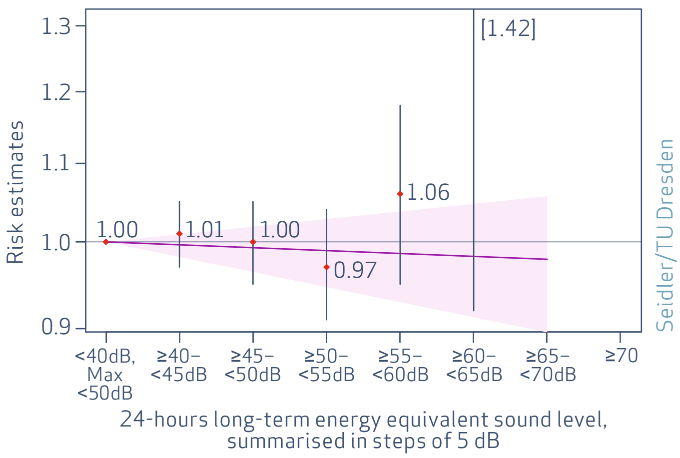
Acute heart attack is the second-most frequent cause of death in Germany. More than 50,000 persons die here every year from circulation problems of the heart muscle. Many factors that increase the risk of heart attack have been known for years, including high blood pressure, severe obesity, and lack of exercise. Different studies in the past have suggested that permanent traffic noise exposure may also increase the probability of suffering a heart attack. The Study on Health Risks dealt with this question with a higher degree of precision than many earlier examinations did – among other things, with more precise noise calculations.

Heart attack risk in figures

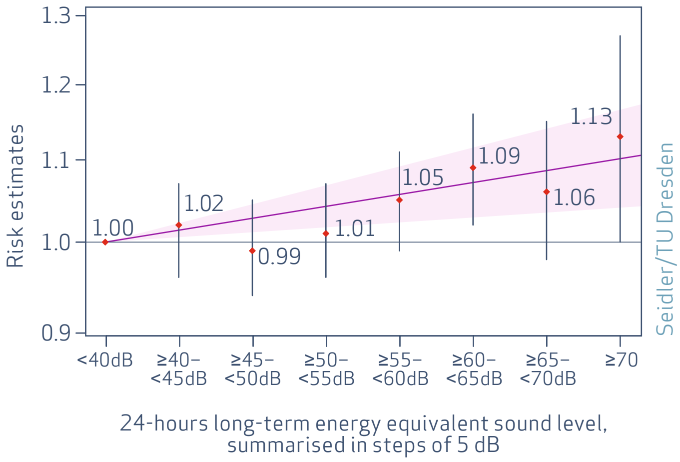
The scientists were able to confirm with NORAH that traffic noise is a heart attack risk factor:

- When the 24-hours long-term energy equivalent sound level (glossary) of road noise increases by ten dB (glossary) the risk of heart attack increases by 2.8 percent.
- The heart attack risk increases by 2.3 percent per ten dB of railway traffic noise.
- Aircraft noise shows no statistically significant (glossary) connection between the evenly increasing noise and heart attack. However, fewer people in the examination area were exposed to loud aircraft noise: only about two percent of the persons had long-term energy equivalent aircraft sound level above 55 dB, and it never exceeded 65 dB. In comparison: the road sound level for26 percent and the railway sound level for seven percent of the insured persons exceeded 55 dB. Therefore, it is more difficult to depict the risk relationship for aircraft noise.

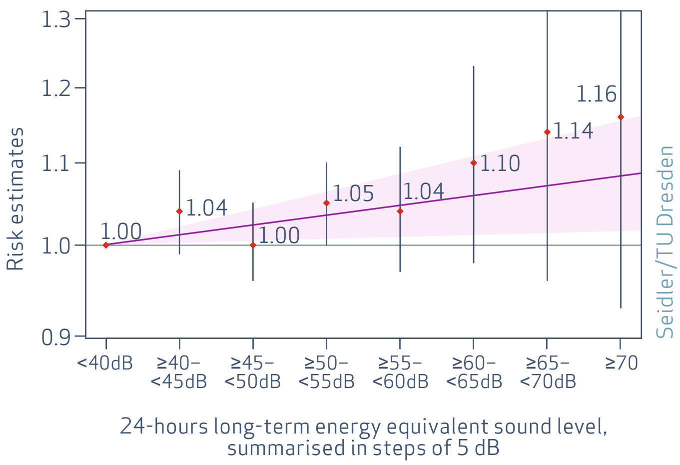
Heart attack and aircraft noise



Heart attack and road noise



Heart attack and railway noise



Deceased heart attack patients: connection to aircraft noise found

Heart attacks often have a fatal result. 53 percent of the insured persons who had a heart attack according to health insurance data from 2005 to 2010 had already died by 2014/15. However, the NORAH team did not know what they died of. For this partial group, the scientists performed separate analyses. They were able to document a statistically significant connection in the persons affected between aircraft noise exposure and heart attack risk – among other things if the 24-hour-long-term energy equivalent sound level at their addresses was 60 dB or above. An aircraft noise increase of ten dB increased the risk of fatal heart attack by 3.2 percent. For road and railway noise, similarly high risks were found. The results suggest that traffic noise is not only a risk for the occurrence, but also for the severe progression of a heart attack.

AIRCRAFT NOISE
The figure shows no statistically significant risk change, since the "basic risk" of 1.0 is within the light-violet shaded 95%-confidence interval.

ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 2.8% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 2.3% per 10 dB (statistically significant).

STROKE: CLEAR DIFFERENCES BETWEEN NOISE TYPES

In the last years, the number of deaths from stroke has dropped considerably. Nevertheless, the sudden circulation disorder of the brain or bleeding in the brain is still among the most frequent causes of death in Germany. More than 18,000 persons died of a stroke in 2013. The known risk factors include, among other things, being overweight, smoking and hypertension. The NORAH study was able to prove that all three examined traffic noise types also influenced the stroke risk.

Road and railway noise: long-term energy equivalent risk increases with increasing long-term energy equivalent sound levels

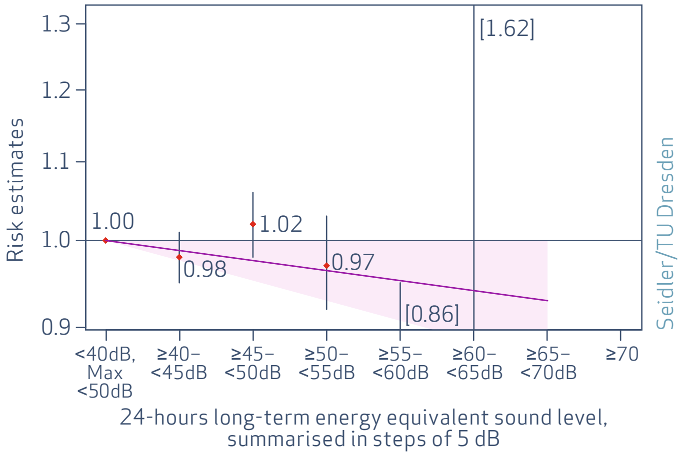
The NORAH team was able to find a statistically significant (glossary) connection to strokes, both for noise caused by trains and for car noise:

- When the 24-hours long-term energy equivalent road sound level (glossary) increases by ten dB (glossary), the risk of stroke increases by 1.7 percent.
- For railway noise, the stroke risk increases by 1.8 percent per ten dB.
- There was no increase in stroke risk with regards to aircraft noise, but as the long-term energy equivalent sound level increased, there was a decrease in risk.

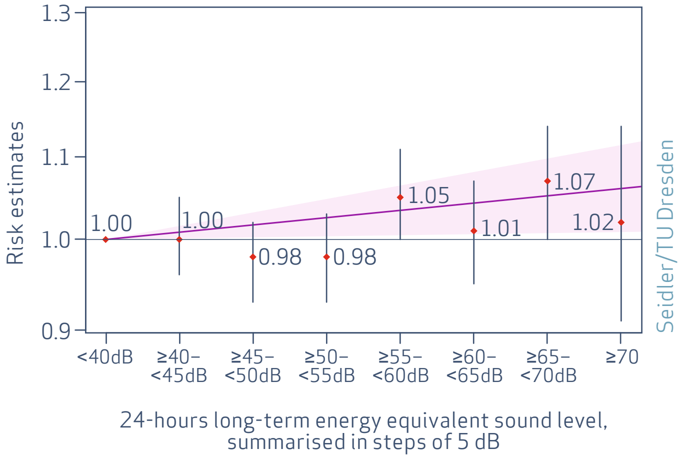
Aircraft noise: does maximum noise play a role?

Most calculations of the NORAH team were based on long-term energy equivalent sound levels. This physical value averages the number and sound level of the individual sounds within a specific period – e.g. 24 hours. Additionally, the scientists also considered the maximum sound level (glossary): the maximum sound level that reaches an address when a car, train or aircraft passes nearby. For aircraft noise, the NORAH team found a statistically significantly increased stroke risk in persons with a long-term energy equivalent sound level below 40 dB if the maximum sound level at night exceeded 50 dB.

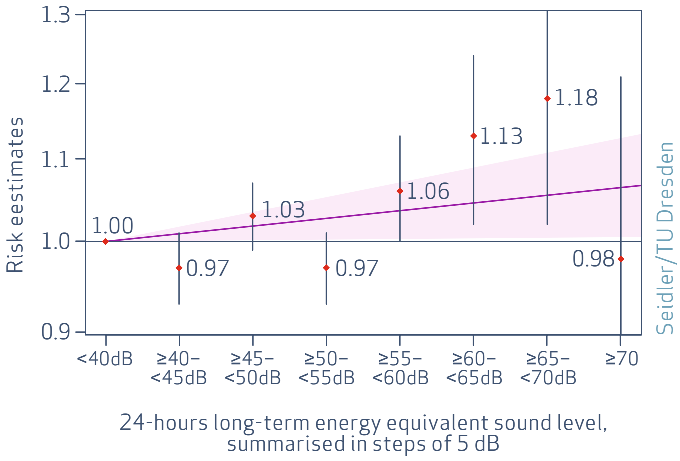
Stroke and aircraft noise



Stroke and road noise



Stroke and railway noise



AIRCRAFT NOISE
The figure shows a linear risk decrease (violet line) of 2.4% per 10 dB (statistically borderline significant).

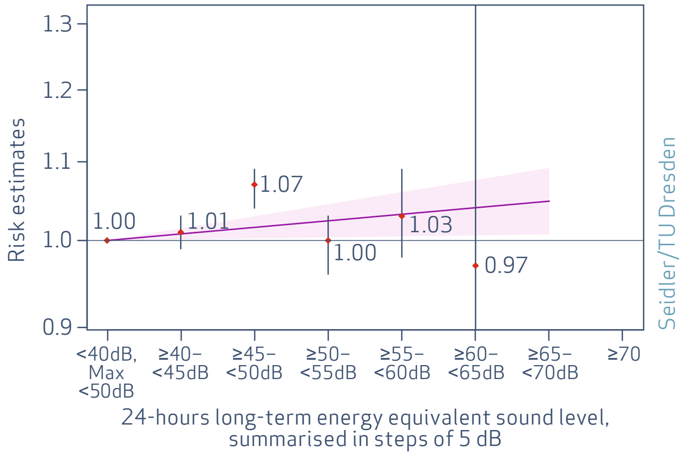
ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 1.7% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 1.8% per 10 dB (statistically significant).

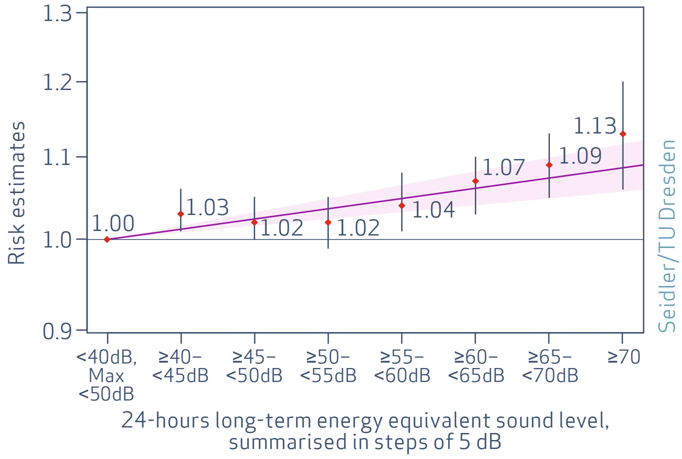
CLEAR RESULTS FOR CARDIAC INSUFFICIENCY

Doctors speak of cardiac insufficiency when the heart is no longer able to sufficiently supply the body with blood. This disease, commonly called heart failure, may have many causes. In many patients, the coronary vessels and, as a consequence, the heart muscle, are damaged. High blood pressure also facilitates cardiac insufficiency. Even though the patients have a better survival chance than stroke or heart attack patients, cardiac insufficiency is the third-most frequent cause of death in Germany. 45,815 persons died of it in 2013.

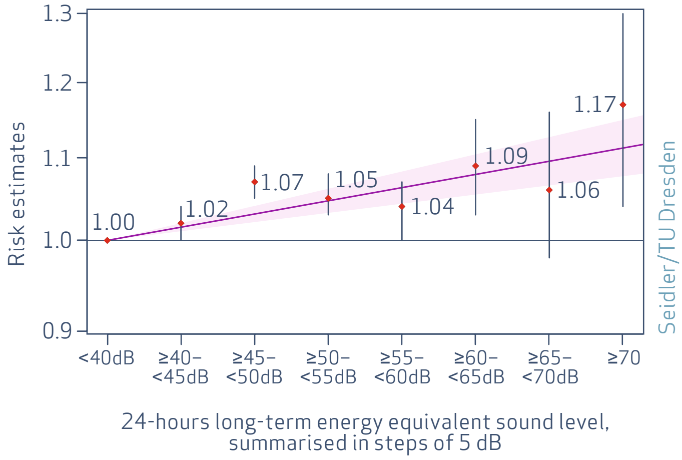
Cardiac insufficiency and aircraft noise



Cardiac insufficiency and road noise



Cardiac insufficiency and railway noise



AIRCRAFT NOISE
The figure shows a linear risk increase (violet line) of 1.6% per 10 dB (statistically significant).

ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 2.4% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 3.1% per 10 dB (statistically significant).

Connections with all three traffic noise types found

Aircraft noise, as well as railway and road noise, statistically significantly (glossary) increase the risk of developing cardiac insufficiency.

- The connection is the clearest with railway noise: per ten dB (glossary), the risk of cardiac insufficiency increases by 3.1 percent.
- Road noise increases the risk of cardiac insufficiency by 2.4 percent when noise increases by ten dB.
- At 1.6 percent per ten dB, the risk increase under the influence of aircraft noise is a little lower – but even this result is statistically significant.

Additionally, the aircraft noise results tend to be less certain than the road and railway noise results, since aircraft sound levels above 65 dBs did not exist in the area under examination. Additionally, the data suggests that the time of residence plays a role: according to this, the risk of cardiac insufficiency may increase in persons who lived in noisy areas for several years. This assumption needs to be tested by further studies.

Survey to supplement health insurance data

The scientists took things a step further for cardiac insufficiency: they not only analysed the health insurance data, but also used an additional survey to collect and analyse information regarding risk factors for cardiac insufficiency or hypertensive heart disease. For this, the health insurers wrote to some of the insured persons. About 3,000 persons suffering from cardiac insufficiency or hypertensive heart disease and a high number of "control persons" not suffering from cardiac insufficiency or hypertensive heart disease reported to the survey collection office in Gießen and subsequently participated in the in-depth survey.

The NORAH team could use data collected based on the in-depth survey to ensure that the traffic noise risks found for cardiac insufficiency or hypertensive heart disease could not be explained by other factors. This suggests that the increased disease risks are actually caused by traffic noise.

Noise within the apartment considered

Additionally, thanks to the additional information, the scientists could gain insight on how loud the apartments of the respondents actually were. For this, the participants reported, among other things, the orientation of their bedrooms at home and whether the bedroom window was preferably tilted open or closed at night. From this information, the NORAH team initially estimated the sound level inside the apartment and then the cardiac insufficiency risk depending on the interior sound level.

The result: generally, the risk estimates increase when the interior sound level is considered instead of the exterior levels. This is true for aircraft noise, road noise and railway noise. This result generally suggests that traffic noise can cause cardiac insufficiency.

MORE DEPRESSION FOR TRAFFIC NOISE

The scientists found statistically clear connections for depression. The noise from aircraft, cars and trains increases the risk of suffering from a depressive episode. The disease, which usually happens in episodes, is one of the most frequent mental illnesses in Germany. Every fifth person experiences at least one depressive episode in his or her life. The causes of depression are diverse, and usually several factors come together. One possible factor is stress, which in turn may be caused by chronic traffic noise.

Clear connection with all three noise types

In fact, the scientists were able to find a connection between traffic noise and the medical diagnosis of a depressive episode with NORAH. Increases of the long-term energy equivalent sound level (glossary) by ten dB (glossary) increases the depression risk

- by 8.9 percent for aircraft noise.
- by 4.1 percent for road noise.
- by 3.9 percent for railway noise.

The data also suggests the time spent living in the noisy area may also influence the risk of depression. Future studies should follow-up on this result of the NORAH study.

Both the noise from aircraft and that of cars and trains increases the risk of suffering from a depressive episode.

The risk drops in very loud regions

Included among the rather unexpected results of the study were the results for depression with aircraft and railway noise: the curve is an inverted U. This means: the risk for depressive disease first increases with rising noise levels. In areas with very high aircraft or railway noise exposure, however, the estimated risk drops again. The cause of this, compared to the other results, unusual distribution cannot be determined by the NORAH study.

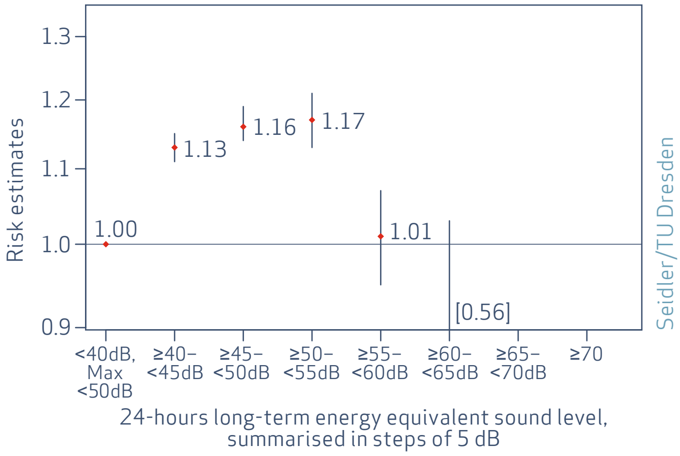
One explanation may be that persons who suffer more from noise and are more prone to developing depression, move less often to areas with high aircraft or railway noise exposure or may move away from these areas more often. Whether this is accurate, and why this is different for road noise compared to aircraft and railway noise must be determined in future studies.

AIRCRAFT NOISE
The depression risk increases first with rising noise, but drops again at high noise exposures. This figure shows no linear risk increase, but the risk estimates for each 5-dB-steps. The vertical dashes above and below the risk estimates indicate the "confidence interval" in which the actual value will be found with a likelihood of 95% (also see reading aid on page 5). From this data, an increase of the depression risk of 8.9% per ten dB can be calculated (statistically significant).

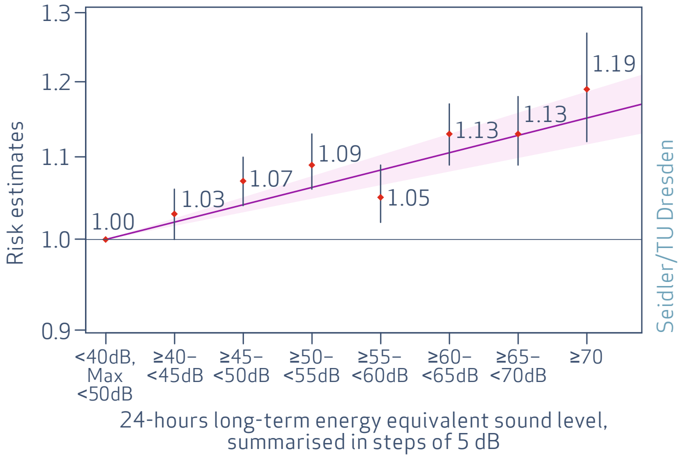
ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 4.1% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The depression risk increases first with rising noise, but drops again at high noise exposures. This figure shows no linear risk increase, but the average risk estimates for each 5-dB-steps. The vertical dashes above and below the risk estimates indicate the "confidence interval" in which the actual value will be found with a likelihood of 95% (also see reading aid on page 5). From this data, an increase of the depression risk of 3.9% per 10 dB can be calculated (statistically significant).

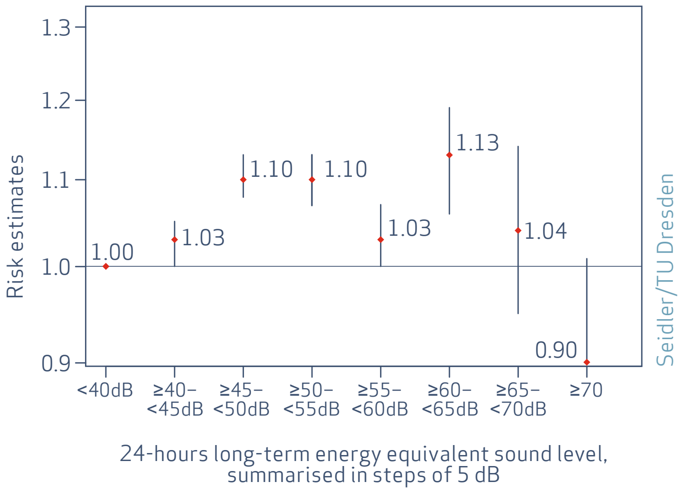
Depression and aircraft noise



Depression and road noise



Depression and railway noise



HARDLY ANY CONNECTIONS DISCOVERED FOR BREAST CANCER

Three studies in past had suggested that traffic noise also promotes the development of breast cancer. However, there were much fewer indications for this assumption than for other diseases examined by NORAH. Breast cancer is one of the most frequent cancers in Germany: the tumour disease is diagnosed in approx. 70,000 women in the Federal Republic every year.

There are hardly any indications of a connection between the breast cancer risk and traffic noise

The scientists were unable to find any connection between the 24-hour long-term energy equivalent sound level (glossary) and the breast cancer risk. The type of traffic causing the noise – aircraft, cars or trains – plays barely any role for the development of the disease.

The only exception is loud aircraft noise at night

The NORAH team was able to find a statistically significant (glossary) connection between noise and breast cancer only for a very small part of the insured persons: women, at whose places of residence the long-term energy equivalent sound level between 11 p.m. and 5 a.m. was between 55 and 60 dB (glossary), were nearly three times as likely to develop breast cancer than other women. However, the authors note that the insured persons only included 145 women from places of residence where the aircraft noise exposure was so high. Six of them had been diagnosed with breast cancer. Since 2011, Frankfurt has had a prohibition of planned flights between 11 p.m. and 5 a.m.; therefore, the long-term energy equivalent sound level during this time is now clearly reduced.

The scientists were unable to find any connection between the 24-hour long-term energy equivalent sound level and the breast cancer risk.

INTERVIEW WITH STUDY MANAGER PROF. DR ANDREAS SEIDLER: “NOISE MAY ALSO INFLUENCE THE PROGRESSION OF DISEASES”

Prof. Dr med. Andreas Seidler, institute director at the Technical University of Dresden, manages the Study on Health Risks. In the interview, the epidemiologist (glossary) and occupational physician tells how he interprets the results and which he found the most surprising.

Stephan Wiegand

Prof. Dr med. Andreas Seidler from the Technical University of Dresden (Institute of Occupational and Social Medicine) manages the Study on Health Risks.

NORAH Knowledge: Which results were surprising for you?

Andreas Seidler: Several! I had not expected, for example, that for heart attacks, we would find clear differences between the overall group and the partial group of deceased patients: the risk of fatal heart attack was higher in all three noise types than the risk for a new heart attack in general. This makes us wonder if traffic noise may not only be relevant for the occurrence of the disease, but also for the progression. I also find it interesting that we found similar, statistically significant exposure-risk relationships for the disease with the most cases: cardiac insufficiency.

Thirdly, the continually high health risks for the indoor levels surprised me. The noise inside the apartments – for the sleeper – can only be estimated very generally. These uncertainties of noise determination could blur the risks. The fact that we found increased risks suggests a causative effect of the traffic noise.

In addition to the analysis of the health insurance data, you conducted a in-depth survey with some insured persons. How do the answers contribute to your results?

With the in-depth survey we sought to determine using the example of cardiac insufficiency, whether the results from the health insurance data would be confirmed, or whether known risk factors such as social status, smoking or sports had distorted the results. When we consider these confounding factors, our results remain nearly unchanged. This suggests that the results derived from the health insurance data are highly indicative.

For strokes, it seems as if the health risk sinks with increasing aircraft sound levels. How do you explain this?

We should remember two things: one, we see particularly clearly in the case of strokes that the maximum level (glossary) is relevant as well. We examined the group of persons separately where the long-term energy equivalent sound level (glossary) was less than 40 dB (glossary), but the maximum sound level above 50 dB. In this group, we find statistically significant increased risks. Apparently, the long-term energy equivalent sound level of aircraft noise is not enough to describe the aircraft noise effect – we also must look at the maximum sound level.

Another reason may be that none of the insured persons were exposed to an aircraft sound level above 65 dB – in contrast to road and railway noise. And when looking at the long-term energy equivalent sound level range above 55 dB, only about two percent of the included population had an long-term energy equivalent aircraft sound levels exceeding 55 dB. For railway noise, however, seven percent were above it; and 26 percent for road traffic. If higher level values barely occur in aircraft noise, or are missing entirely, the entire curve progression becomes less certain.

For depression, the risk due to aircraft and railway noise seems to increase first and then drops again in the louder regions. What might be the reason?

Relatively few persons were exposed to higher sound levels of aircraft and also railway noise – much fewer than in the case of road noise. This makes the results less certain. However, this is not a sufficient explanation. Future studies should examine whether moving plays a role. We have looked at the depression risks for those persons we knew did not move in the last five years. In this group, we found statistically significant increased depression risks for the highest aircraft noise exposures.

Professor Seidler, thank you for the interview!

FUTURE RESEARCH NEEDS

As with every scientific examination, the Study on Health Risks not only answered questions, but also brought up new ones. In particular, the authors of the study see further need for research in five areas.

1 What is the role of the maximum sound level?

Noise effect studies use mostly the long-term energy equivalent sound level (glossary) – an average of the number and volume of "noise events". The Study on Health Risks suggests that the maximum sound level (glossary) – i.e. the maximum volume of individual noise – may also influence the health risks, especially for aircraft, but also for railway noise. Future traffic noise studies should deal with the question of how to use both measures to better describe the effect of traffic noise.

2 More research required on traffic noise and depression

The clear connection between traffic noise and depression, as well as the reduced risk at higher aircraft or railway sound levels, give reason for further research. Future studies should deal, for example, with whether persons bothered by noise move more often to calmer areas and whether depressive diseases influence moving.

3 Does traffic noise influence the progression of diseases?

Future studies should deal with the question of what influence traffic noise has, not only on the occurrence of the disease, but also its progression.

4 After what time will traffic noise increase the health risk?

The Study on Health Risks has also included past noise exposure where possible. Considering the duration of noise exposure, the health risks increase in part. However, it is not definitively clear after how many years what effect occurs.

5 Connection between aircraft noise and breast cancer?

The results suggest only a possible influence of high nocturnal aircraft noise exposure on the breast cancer risk. Whether there actually is a connection should be determined by future studies.

Glossary

You will find further explanations in the glossary on **www.laermstudie.de**.

Long-term energy equivalent sound level
The long-term energy equivalent sound level (in short: L_{pAeq}) is a measure for the average noise exposure over a certain period in which frequency, duration and level of the individual sound events are taken into account. The L_{pAeq} is the basis for the determination of noise protection zones pursuant to the aircraft noise act – separated according to day (6 a.m. – 10 p.m.) and night (10 p.m. – 6 a.m.). The L_{pAeq} is stated in dB.

Decibel
The decibel – "dB" or "dB(A)" – is a measure of sound pressure level and thus of loudness. The decibel scale from 0 to 120 dB(A) reflects the range from the absolute threshold of hearing to the pain threshold. The scale is not linear. We perceive an increase of ten decibels as roughly a doubling of the loudness – in the lower and at the upper ends of the range.

Epidemiology
Epidemiology is the study of the distribution of risk factors and diseases in populations. It contributes towards a better understanding of the cause of disease. Epidemiology develops measures to prevent disease or to prevent the spread of disease. It also helps to develop strategies for the treatment of diseases.

Exposure-effect relationship
The results of noise impact studies such as NORAH can often be expressed in exposure-effect relationships. This means that the scientists quantify as accurately as possible at which traffic noise exposure the risk of a certain disease increases by how much.

Maximum sound level
The physical value which best describes how strongly nocturnal aircraft noise impacts sleep is the maximum sound level. It shows to what extent aircraft noise stands out from the existing background noises. The overall annoyance effect depends on the level and the frequency of occurring maximum sound levels.

Pseudonym
In everyday usage a "pseudonym" is a false name, artist's name or code name. The pseudonym makes it impossible to trace statements back to the author personally. The Federal Data Protection Act defines pseudonymisation as "substituting a person's name and other identifying characteristics with a label, in order to preclude identification of the data subject or to render such identification substantially difficult." In other words: features that can identify the individual person – for example the name – are substituted with a code, for example a randomly selected number. All of the personal details have to be substituted so that it is not possible to identify a person.

Statistical significance
In simplied terms, statistics speak of a significant effect when it is very unlikely (usually less than five percent) to be a random effect. Statistical significance is determined by calculations.

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Quality of Life
Health
Development

NORAH
Knowledge No. 10

NORAH noise impact study

Aviation noise and nocturnal sleep

Results

forum flughafen & region
umwelt- und nachbarschaftshaus

NORAH Knowledge No. 10

NORAH Noise Impact Study

Aviation noise and nocturnal sleep

Results

"NORAH Knowledge" provides information on the methods and results of the NORAH noise impact study. The aim of this series is to communicate to as many people as possible what exactly NORAH had been researching. This is why there is an explanation in the glossary at the end for all terms marked "Glossary".

If you would like to receive further issues of "NORAH Knowledge", please use the enclosed order form.

The NORAH Study investigated the effects of aviation, road and rail noise on people.

von Aichberger

Contents

NORAH (“Noise-Related Annoyance, Cognition, and Health”) is the most extensive investigation into the effects of exposure to aviation, road and rail traffic noise that has ever been carried out in Germany. It is being conducted by nine independent scientific institutes from all over Germany. The client is the Umwelt- und Nachbarschaftshaus, a subsidiary of the Land of Hessen and part of the Frankfurt Airport and Region Forum. Alongside the land of Hessen, communities, Fraport AG and Lufthansa were also involved in the financing.

The NORAH Study examined the long-term effects of traffic noise on health, quality of life and early childhood development in the Rhine-Main Region. The initiator of the study is the Airport and Region Forum (ARF). The scientists were accompanied from the start by an external Scientific Advisory Board for Quality Assurance (WBQ). This is what distinguishes NORAH from similar, predecessor studies. The study addressed some of the most topical important issues currently being dealt with by international noise impact research. It also covered a wider range of investigation aspects than previous studies. In order to find out more about how human beings respond to traffic noise, the NORAH scientists also looked at the medical histories of more than one million people, and reconstructed the noise exposure at around 900,000 addresses in the Rhine-Main Region.

A total of five sub-studies form the core of the NORAH Study. Each one built on the current international state of research. In addition to this, extremely complex and innovative techniques were used to calculate the acoustic exposure. In this edition of “NORAH Knowledge” we present the results of the sleep study, one of the five sub-studies.

Further information on the NORAH Study is available on the Internet at **www.laermstudie.de**. There you can also subscribe to the newsletter “NORAH Brief”.

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OVERVIEW OF THE SLEEP STUDY

We sleep on average just over seven hours every night. Just how important this rest phase is, is clear to anybody who has ever had too little sleep at night. It is not always easy for people living in the proximity of airports to settle down at night and find sleep. The NORAH Sleep Study examined how nocturnal flights affect people's sleeping habits. The study paid special attention to the effects of two new measures, which changed the noise background in the Rhine-Main Region in October 2011. Since then there has been a curfew at Frankfurt Airport on scheduled take-offs and landings between 11 pm and 5 am. At the same time, the new North-West runway began operations. A comparison of the sleep measurements from 2011 and 2012 shows how the changes affected residents with otherwise healthy sleep patterns.

Measuring sleep quality in the proximity of the airport

In order to answer their research questions, the scientists carried out sleep measurements directly in the bedrooms of residents around Frankfurt Airport in the summers from 2011 to 2013. Over 200 persons took part in the measurements, many of them over two or all three years. The study participants spent three to four successive nights with several electrodes attached to their bodies. While they were sleeping, the electrodes recorded the brain activity, the heartbeat and other physical signals. A sound level meter also registered all nocturnal noises reaching the ears of the sleeping individuals. This allowed the NORAH team to calculate how overflights affect people's sleep. All of the participants provided other information in questionnaires – including how they subjectively perceived their sleep and how positive or negative their attitude is towards air traffic.

Quieter nights improve the sleep quality

The curfew on scheduled flights between 11 pm and 5 am since October 2011 has had a positive effect: as fewer overflights could be heard in the bedrooms in 2012, the people generally woke up less frequently (glossary: wake-up reaction). Persons who went to bed between 10 and 10.30 pm, and got up between 6 and 6.30 am woke up on average less frequently than those who went to bed and got up one hour later. The latter were more frequently woken on average in the early morning hours by aviation noise.

Increased tiredness in the morning

Although the measurements show that the study participants in 2012 woke up less frequently on average than in 2011, this positive development is not reflected in the perception of the people themselves: they felt somewhat more tired and sleepy in the mornings than in the previous year in each year of the investigation at the same noise exposures, but in all years in the middle range of the tiredness scale. The scientists are unable to derive any explanation for this effect from the data. It must, therefore, be due to factors not examined by the study.

People with a critical attitude towards air traffic tend to sleep less well

Some of the questions asked by the NORAH team addressed the attitude of the participants towards air traffic. On the basis of the responses and the sleep measurements it was shown that people who have a more negative attitude towards air traffic slept less well. They needed longer to fall asleep, lay awake for longer at night, and spent less time in deep sleep. Whether the poorer quality of sleep is the result or the cause of the negative attitude towards air traffic cannot be established on the basis of the data.

Results from Cologne/Bonn not reliably transferrable to Frankfurt

As far back as 2001 and 2002 the German Aerospace Centre (DLR) had measured the sleep quality of residents around airports, not in the Rhine-Main Region, however, but in the area of Cologne/Bonn Airport where a lot of freight planes are taking off and landing more or less continuously during the night. Noise abatement calculations and indices (glossary: Frankfurt Aviation Noise Index) at several airports are based on the results of this investigation. Within the framework of the sleep study, the NORAH team has now found out that the results from then cannot be readily transferred to the current situation at Frankfurt Airport. The people in Cologne/Bonn slept less well in 2001 and 2002 than the participants in the Rhine-Main Region in 2012 after the introduction of the curfew on scheduled flights between 11 pm and 5 am. At the same time, the NORAH participants felt more annoyed by nocturnal aviation noise.

Wavebreakmedia/Shutterstock

The curfew on scheduled flights between 11 pm and 5 am since October 2011 has had a positive effect: as fewer overflights could be heard in bedrooms in 2012, the people woke up less frequently.

METHOD AND QUESTIONS OF THE SLEEP STUDY

How severely do take-offs and landings of aircraft during the night disturb people's sleep? When and how often are residents around airports who actually have healthy sleeping habits woken up additionally by overflights? Dr. Uwe Müller from the German Aerospace Centre (DLR) in Cologne and his team searched for answers to these questions in the region around Frankfurt Airport. Alongside Germany's largest airport, the region also offers another special feature: since October 2011 Frankfurt Airport is subject to a curfew on scheduled flights between 11 pm and 5 am. Also, in the same month the new North-West runway began operations. The NORAH team was thus able to examine whether the residents slept any differently after these changes in the noise levels.

Noise as a participation criterion

More than 200 persons took part in the study between 2011 and 2013; the criterion for their selection was the noise that reaches their bedrooms. Aviation noise had to be clearly audible, but with hardly any road or rail noise. Another criterion: the study participants had to have a regular sleeping rhythm and healthy sleeping patterns. People who worked shifts or suffered from disorders that influence sleeping patterns were not accepted as participants. This rigorous selection was important in order to rule out as far as possible causes for sleep disorders other than noise.

Precise sleep measurement

The sleep measurements of all the participants formed the core of the study. Just like in a sleep lab (Glossary), in 2011 and 2012 the NORAH team "wired" the men and women in the evening before going to bed with several electrodes on head and body. This allowed them to record various physical signals while the people were sleeping. At the same time a sound level meter registered all noises that reached the ears of the sleepers during the night. The data allowed the scientists to analyze precisely how deeply the participants were sleeping, and when and how they reacted to overflights of planes.

Three measurement phases

The first measurements took place in the summer of 2011, i.e. before the introduction of the curfew on night flights between 11 pm and 5 am, and the opening of the North-West runway. There were further measurement phases in the summers of 2012 and 2013. For three to four nights in a row the NORAH team recorded the sleep of each participant.

Questionnaires surveyed the personal sleep perception

In addition to the sleep measurements, the scientists also asked the participants to assess their own sleep after each measurement night – for example whether they felt tired and sleepy in the morning. The respondents also provided information on, among other things, their noise sensitivity and their attitude towards air traffic.

A project worker attaches the electrodes to a study participant before going to bed. The participants slept with the electrodes attached to their body for three of four nights in succession.

Knost, DLR

Search for a new method of sleep measurement

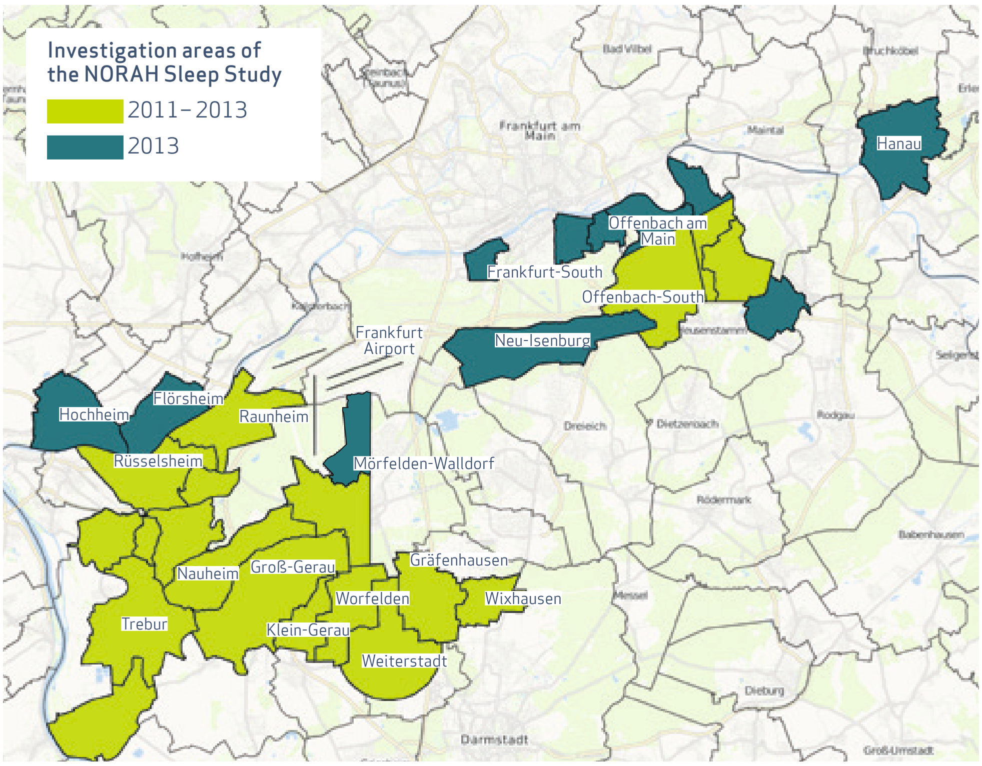
The study participants slept in their own beds during the measurements. For the investigations in 2011 and 2012 they wore ten electrodes on the head and two on the body. Because this type of investigation – sleep researchers refer to “polysomnography” (Glossary) – is very complex, the NORAH team developed a simpler method for 2013. The scientists had already begun the preliminary work for such a method back in 2008. The new “vegetative-motor” method only needs two electrodes and is easier to evaluate. This is why more people could take part in the third year of the investigation than in the previous years. The new method, however, does not measure the same things as polysomnography, but only registers changes in the heartbeat and body movements.

The special feature of the NORAH Sleep Study

In the area of sleep research, NORAH goes further than many other studies: most investigations up to now had to make do with questionnaires. Only a few noise impact studies before NORAH worked with polysomnographic methods on the residents on site – including a study carried out around Cologne/Bonn Airport in the years 2001 and 2002. Its results were used for the Frankfurt Night Flight Index (Glossary “Frankfurt Aircraft Noise Index”). One of the tasks of NORAH was to examine whether the results of this older study could be transferred to the Frankfurt region. No study anywhere in the world before the NORAH Sleep Study carried out polysomnographic investigations on such a large number of participants in their own homes.

You can read more about the method and tasks of the sleep study in “NORAH Knowledge” 5.

Areas where the NORAH Sleep Study was carried out



Open Street Map / UNH 2015

THE QUALITY OF SLEEP IN THE RHINE-MAIN REGION

The results of the NORAH Sleep Study show for the first time in detail how well people with otherwise healthy sleeping habits in the Rhine-Main Region sleep, and how aviation noise affects their nightly rest. The first sleep measurements were carried out in 2011 before the curfew on scheduled flights between 11 pm and 5 am came into effect. All of the participants went to bed between 10 and 10.30 pm, and got up between 6 and 6.30 am. The second measurement phase took place in 2012. In this year, almost all of the participants from the previous year took part again. In 2012 the NORAH team also investigated another group of persons who went to bed an hour later, i.e. between 11 and 11.30 pm, and also got up an hour later in the morning. Comparison of the two groups allowed the NORAH team to estimate how the six-hour night flight curfew affected the sleep of the residents, and whether when the participants went to bed and got up again made any difference in the second year.

Early sleepers benefit from the flight curfew between 11 pm and 5 am

Due to the lower number of overflights in 2012, study participants who went to bed between 10 and 10.30 pm slept better in the second year of the investigation. In 2011 they awoke additionally on average 2.0 times per night at the time of an overflight ("aviation noise-associated wake-up reaction"). In 2012, however, they woke up additionally on average only 0.8 times per night due to overflights.

Late sleepers wake up more frequently

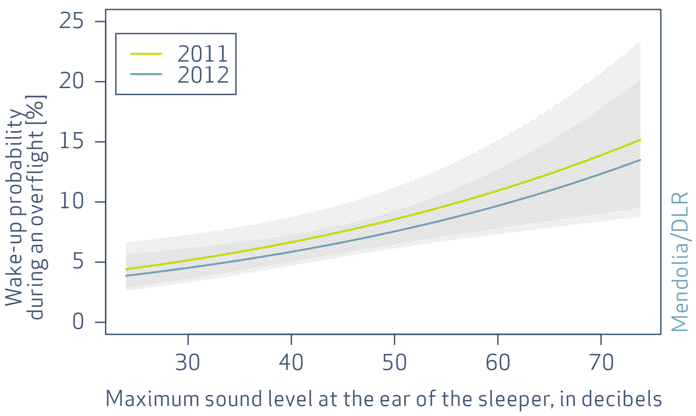
The second group of participants in 2012, who went to bed between 11 and 11.30 pm and got up an hour later in the morning than the "early sleepers", woke up more frequently. On average 1.9 times per night they experienced an "aviation noise-associated wake-up reaction", i.e. an interruption of their sleep during an overflight. The reason for the clear difference between early and late sleepers: the getting up time of the late sleepers was around two hours after the end of the curfew on scheduled flights. This meant that the people were exposed for longer to the resuming air traffic in the early morning.

Not every overflight causes the same degree of disturbance

Most of the overflights did not cause the sleepers to wake up. The NORAH team wanted to know more exactly whether some overflights disturbed sleep more than others. To do this they analyzed, among other things, the maximum sound level (Glossary), i.e. the maximum loudness of each overflight, and the time. They found out – unsurprisingly – that louder overflights lead to more frequent wake-ups. However, the difference between the general background noises and the maximum sound level of the overflight also played a role: if the background noises were louder and the difference to the overflight noise therefore less, the participants woke up less frequently. The time also plays a role: towards the end of the night, when the sleep pressure decreased, the participants were more likely to wake up than at the start of the night.

Towards the end of the night, when the sleep pressure decreased, the participants were more likely to wake up than at the start of the night.

Aviation noise-associated wake-up probability



The graph shows the probability of waking up during an overflight with a certain maximum sound level. The wake-up probabilities for 2011 and 2011 are not significantly different (Glossary). This is apparent from the strong overlap of the shaded “confidence intervals”.

How the participants slept

Despite the different noise exposure in the years 2011 and 2012, the scientists were unable to establish any significant differences in various sleep characteristic values between the two years. In order to track down possible effects of nocturnal aviation noise, the NORAH team had measured, among other things, how long the participants lay awake at night and how long they needed to fall asleep.

In none of the investigated sleep characteristic values (see table) were the scientists able to establish any statistically significant differences between the years and groups. Here an overview of the average values:

People with a more critical attitude towards air traffic sleep less well

The NORAH team also asked the participants how positively or negatively they viewed air traffic, and how necessary they believe it is. The answers hardly changed over the course of the three investigation years. However, in all three years the scientists were able to establish a connection between the sleep of the participants and their attitude towards air traffic: residents with a more negative attitude towards the airport needed longer to fall asleep, spent less time in deep sleep, and lay awake at night for longer.
The scientists were unable to draw any conclusions from the data as to cause and effect: the negative attitude could be a result of the poor sleep, but it is also possible that the negative attitude could be the cause for poor sleep.

None of these six investigated sleep characteristic values showed significant differences between the years or the groups.

	2001: Sleep time: 10/10.30 PM to 6/6.30 AM	2012: Sleep time: 10/10.30 PM to 6/6.30 AM	2012: Sleep time: 11/11.30 PM to 7/7.30 AM
Total sleep duration	7:06 hours	7:08 hours	7:07 hours
Time between going to bed and falling asleep	13.9 minutes	14.5 minutes	13.1 minutes
Sleep efficiency (proportion of sleep to time in bed)	90 %	90 %	91 %
Duration of waking after falling asleep	36.7 minutes	34.4 minutes	33.8 minutes
Difference between planned and actual end of sleep	3.3 minutes	5.4 minutes	5.7 minutes
Waking proportion in percent between 4.30 am and planned end of sleep	14 %	14 %	12 %

Mendolia/DLR

Measurement of physical reactions to noise changes

In 2013, the third year of the investigation, the scientists used a less complicated measurement method with just two electrodes: this registers how frequently the participants react physically to overflights – with accelerated heartbeat and body movements. Unlike the polysomnographic investigations (Glossary) of the previous years, the participants were able to attach the two necessary electrodes in the evening themselves. This meant that, with the same budget, the NORAH team could measure the sleep of considerably more persons than in 2011 and 2012.

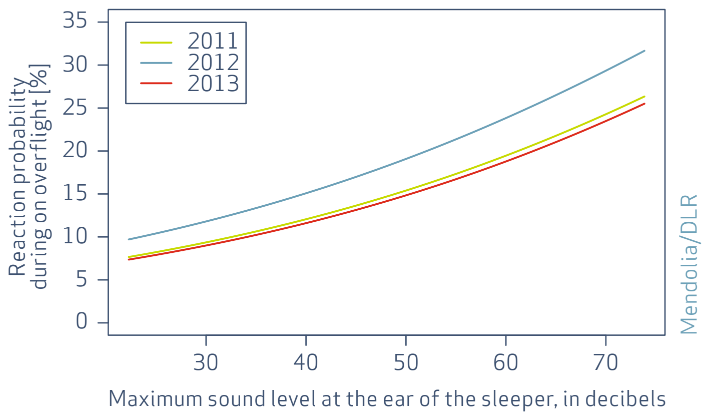
The results show that the physical reactions to overflights increased substantially from 2011 to 2012: in 2011 the participants reacted to 10.7 percent of the overflights with no interference from other noise, in 2012 to 16.2 percent. In 2013 the proportion was 13 percent, i.e. it had fallen back again. The scientists cannot rule out that this may have to do with what is called a change effect. This is what noise impact researchers call it when people temporarily react more strongly to expected or actual noise changes, for example after the expansion of an airport.

The term "wake-up reaction"

In the years 2011 and 2012 the study examined how probable it is that the participants displayed a so-called wake-up reaction due to the influence of aviation noise. This is what the scientists call the change from a deeper sleep phase either to the lightest sleeping phase or waking up.

Wake-up reactions are caused not only by noise. Even in a quiet environment, sleepers will wake up several times in the night. Usually they cannot remember this in the morning. In previous studies in the sleep lab (Glossary), the NORAH team was able to demonstrate that people generally only remember wake-up reactions if they last for longer than 90 seconds.

Aviation-noise associated probability of a "vegetative-motor" reaction



The graph shows the probability of reacting with increased heartbeat and body movements during an overflight with a certain maximum sound level. The reaction probability increased from 2011 to 2012, and then fell back in 2013 to the level of 2011.

THE SLEEP EXPERIENCE FROM THE POINT OF VIEW OF THE PARTICIPANTS

In addition to the sleep measurements, the NORAH team asked all of the participants how they would assess their sleep themselves – after all, the sleep experience and disturbances by aviation noise are to a large degree a question of personal perception.

2011: frequent overflights cause tiredness

The morning after each night of measurements, the NORAH team asked all participants how sleepy and tired they felt. They used several scales for the answers, which are standard in scientific sleep studies. The researchers had expected that the residents subject to a higher noise exposure would also make a more negative subjective assessment of their sleep. And, in fact, for the investigation year 2011, when regular night flights were still taking place, the respondents felt subjectively more tired after a night with a lot of overflights.

2012 and 2013: tiredness increases despite less frequent waking

The scientists were more surprised by the answers of the participants in the second and third year of the study. Because although the sleep measurement showed that the number of overflights and wake-up reactions (Glossary) had decreased, the participants felt increasingly tired and sleepy in the mornings. The introduction of the curfew on scheduled flights between 11 pm and 5 am had thus not caused the people to make a more positive subjective evaluation of their sleep. This result can also be expressed in figures: at the same number of overflights, the negative perception of sleep rose from 2011 to 2013 by five to eleven percent. In total, the subjective sleepiness and tiredness evaluations in all three investigation years were in the middle range of the tiredness scale used. The result was also the same for persons who took part in all three years. The NORAH team thus assumes that uninvestigated and probably non-acoustic factors led to this result.

In 2013 the participants felt more tired and sleepy in the morning than in the previous years.

Sleepiness in the morning after rising

1 → fully awake
8 → very tired, major problems staying awake, fighting against sleep

Tiredness in the morning after rising

0 → wide awake
20 → dead tired

Mendolia/DLR

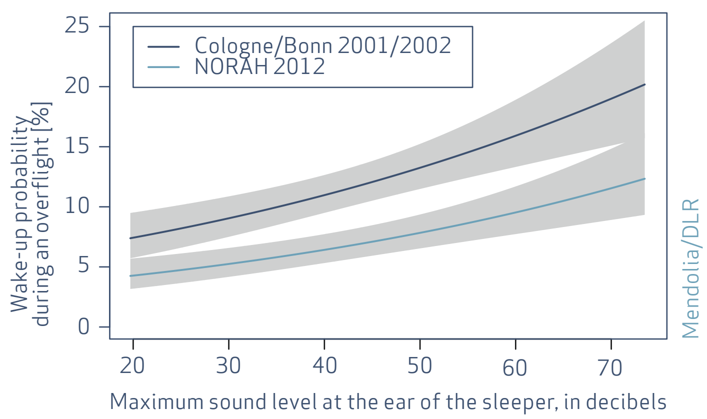
DO RESIDENTS AROUND FRANKFURT AIRPORT SLEEP BETTER THAN THOSE IN COLOGNE?

Around ten years before the NORAH Study, the DLR investigated the sleep quality in the area around Cologne/Bonn Airport. The director of the NORAH Sleep Study, Dr. Uwe Müller, was also one of the researchers who investigated the quality of sleep in the Rhineland in 2001 and 2002. The results of the Cologne/Bonn study still have concrete significance, also for the residents around Frankfurt Airport: they provide the basis for the calculation of the Frankfurt Aviation Noise Indices (Glossary). However, the noise situation in Cologne/Bonn at the start of the millennium was different in important respects to the situation in the Frankfurt region at the time of the NORAH Study: in 2001/2002 there were continuous flights through the night in Cologne/Bonn, in addition to this, the proportion of older freight aircraft was considerably higher. This type of aircraft generates more noise in other frequency ranges than the passenger aircraft which currently makes up most of the flights in and out of Frankfurt Airport. One of the tasks of the NORAH Sleep Study was to examine to what extent the Cologne/Bonn results could be transferred to the Frankfurt region. The researchers established differences in the sleep quality of the previous and present study participants.

People in Cologne/Bonn wake up more frequently

Due to the higher number of nocturnal flights, the residents around Cologne/Bonn airport woke up more frequently. The probability of being woken up by an overflight with a certain sound level was also higher at Cologne/Bonn Airport.

Aviation noise-associated wake-up probability at Frankfurt and Cologne/Bonn airports



The NORAH participants were less likely to wake up during an overflight than the participants of a study carried out in the Cologne/Bonn region in 2001/2002.

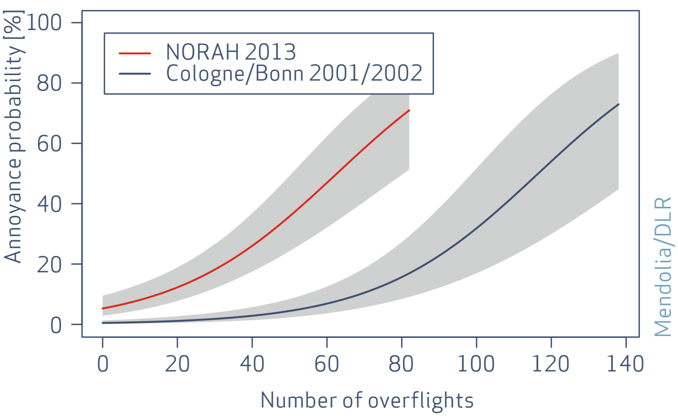
Less time in deep sleep

The residents around Cologne/Bonn Airport got less rest when they were asleep than the Frankfurt study participants after the introduction of the curfew on scheduled flights between 11 pm and 5 am. According to the sleep measurements carried out in the Rhineland, the participants spent less time per night in the deep sleep phase which is so important for rest. There could be several reasons for this difference, which is why the results must be interpreted with care. The NORAH team regards it as possible that they had trouble reaching the deeper sleep phases due to frequent interruptions at the start of the night. The different frequencies of the aircraft types may also have played a role. The NORAH team also regards it as possible that the investigated groups of persons are different. A fourth possible explanation has to do with the fact that the evaluation of sleep recordings is not carried out automatically, but requires a human eye. This is why the people evaluating the two studies may not have interpreted the sleep recordings in an entirely standardized manner.

Annoyance higher in Frankfurt than in Cologne/Bonn

In addition to the sleep measurements, the scientists also asked the participants in both studies how severely they felt annoyed by the aviation noise of the previous night. Here they established that the study participants in the Frankfurt region felt considerably more annoyed by similar noise levels and a similar number of overflights than the respondents ten years before in the Rhineland. It is not possible to derive an explanation for this result from the data. It does, however, correlate with the results of the NORAH Quality of Life Study.

Aviation noise-associated wake-up 'probability at Frankfurt and Cologne/ Bonn airports



Compared with a study in the area of Cologne/Bonn Airport in 2001/2002, the participants of the sleep study in 2013 felt considerably more annoyed by the same number of nocturnal overflights.

NEW METHODS FOR THE ASSESSMENT OF REACTIONS TO NOISE DURING SLEEP

Sleep is much more diverse than most people are aware: during the night, we go through various phases of sleep. Dreams and dreamless phases alternate. Sleep research can measure all these various phases. Polysomnography (Glossary) is regarded as the "gold standard" method here: with the aid of several electrodes attached to the head and upper body of a sleeping person, it is possible to determine precisely which sleep phases the sleeper has reached and when. The method has many advantages – but also a decisive disadvantage for many research projects: it is very complicated. This is why sleep studies often have to make do with very low numbers of study subjects. In order to overcome this obstacle, the NORAH team developed a simpler method in collaboration with US scientists from the University of Pennsylvania which could also be used in the future to analyze noise-impaired sleep – this will, however, require further research. The so-called "vegetative-motor" method requires just two electrodes. The method measures the nocturnal heart frequency and the body movements of sleepers. The US researchers already used the method in 2014/2015, after the NORAH measurements, in a study at the airport in Philadelphia. Further US airports are to follow.

Reactions to aviation noise even during sleep

Scientists cannot draw the same conclusions from the measurement results of the "vegetative-motor" method as from the results of a polysomnographic analysis. It is not possible to tell, for example, which sleep phase a person is in. The measurement results are nonetheless very valuable for NORAH: they show that sleepers react physically to noises, for example aviation noise – with accelerated heartbeat and increased body movements. For many overflights the scientists were able to determine in a comparison of the polysomnographic and the "vegetative-motor" measurement data that, although the sleepers did not wake up, they still reacted physically. Whether these nocturnal reactions have consequences for health will have to be the subject of future studies. The NORAH team regards it as possible, however, that the regularly accelerated heartbeat could, in the long term, increase the risk for cardiovascular disease.

Schmidt, DLR

In the "vegetative-motor" method only two electrodes have to be attached to the body. They measure the heartbeat of the study subject as well as record the physical movements.

INTERVIEW WITH STUDY DIRECTOR DR. UWE MÜLLER: "THE HEART NEEDS TO REST AT NIGHT"

Dr. Uwe Müller from the German Aerospace Centre (DLR) in Cologne directed the NORAH Sleep Study. In an interview the physicist talks about whether the results surprised him, and about how he slept himself during the research project.

Schmitt/DLR

Dr. Uwe Müller directed the NORAH Sleep Study.

NORAH Knowledge: Dr. Müller, what do people need in order to sleep well?

Müller: A dark and quiet environment is very important. They should be able to lie comfortably and switch off from the worries of the day. It also helps to go to bed at roughly the same time every night and with the same routine. We also know from research that the light in the evening should be quite dim so that the sleep hormone melatonin can be released.

Apropos "the worries of the day": worries also play a role in NORAH. People who had a more negative attitude towards air traffic were less likely to sleep well. Do you have any explanation for this?

No, that's like the chicken and the egg. The study design of NORAH does not allow us to determine what was there first. Nonetheless, there is a clear connection: people who objectively sleep less well generally have a more negative attitude towards aviation noise or the airport.

The NORAH participants slept better than the study participants ten years previously in the Cologne/Bonn area. But they still felt more annoyed by aviation noise. How can this be reconciled?

Our results here correlate with those of the NORAH Quality of Life Study. There it was also shown that people felt more annoyed today by aviation noise than they did several years ago. The annoyance depends only to a certain extent on the actual noise exposure. There are also non-acoustic factors that play a role – lack of confidence in the authorities, for example, or in the information provided by the airport, could have an influence. We do not know whether this was the case here. I regard it as plausible, however, that the responses of the Quality of Life Study also apply to our participants.

Which results surprised you in particular?

I was looking forward to seeing whether the wake-up probability in Frankfurt after the introduction of the night flight curfew would differ from the results of the Cologne/Bonn study. In Cologne/Bonn there was continuous night flight operation at the time. There are some moderate differences, which, however, due to the different study conditions, have to be interpreted with great care. For me the result is a further indication that the aviation noise laws for determination of the nocturnal abatement zones in Germany has to finally move away from purely physical and acoustic values towards physiological values such as, for example, the wake-up reaction. And I was delighted that the "vegetative-motor" method worked so well. Although it does not measure the wake-up reactions, it is possible to determine when the heartbeat is accelerated due to aviation noise even if the person does not wake up. The method is therefore more sensitive than the sole consideration of the wake-up reaction. We may have even found one of several possible further explanations of how nocturnal aviation noise could increase the risk of cardiovascular disease. Whether this is actually the case will have to be the subject of future studies.

What might this connection look like?

The "vegetative-motor" method measures heart frequency accelerations and body movements. The heart needs to rest at night. We have found out, however, that overflights interrupt this rest and accelerate the heartbeat. This could lead to cardiovascular problems after long years of noise exposure.

How well did you actually sleep yourself during the NORAH Study?

It was quite mixed! For example, the stress was high in the summers of 2011 and 2012; that also had an effect on my sleep. I was on site at the time to recruit study participants and carry out preliminary investigations. I think it is very important to be on site personally. Sitting at a desk studying noise charts is completely different to experiencing the noise for yourself. At this point I would also express my sincere thanks to all the participants in the sleep study for their interest, their patience and endurance and their time. And thank you also to the project workers and students at the University of Gießen, who gave us decisive support by taking care of the study participants on site in the evenings and in the mornings, as well as the colleagues at the University of Pennsylvania for their valuable and intensive collaboration in the development of the new method.

Dr. Müller, thank you for talking to us!

OUTLOOK

The NORAH Sleep Study investigated how people slept in the Rhine-Main region during the investigation period, how aviation noise influenced their sleep, and how they themselves assessed the quality of their sleep. The scientists also developed a method, which could make it possible in the future to carry out studies with more participants than has hitherto been the case. The sleep study also raised new questions, which will have to be clarified by future studies.

What effects does accelerated heartbeat at night have for health?

With the new "vegetative-motor" method used by NORAH, the focus of the scientists was brought back to the fact that nocturnal overflights can, in many cases, increase the heartbeat of sleepers. It even happens that people appear to continue sleeping peacefully, but still show a physical reaction. The sleep study was able to document these direct reactions. It cannot, however assess whether these reactions can have a negative impact on health in the long term and, for example, increase the risk for cardiovascular diseases. Further studies in the future will have to clarify this.

How often does aviation noise cause waking up?

Even though the "vegetative-motor" method within the framework of NORAH promises a lot of potential for future sleep studies, researchers still attach great importance to the "wake-up reaction" (Glossary) – the transition from a deeper sleep phase to the lightest phase or to waking up. The question as to how frequently aviation noise triggers such a wake-up reaction is not easy to answer. This is because even in a quiet environment sleepers can wake up "spontaneously" during the night. This is why scientists in noise impact studies such as NORAH have to try and find out which wake-up reactions of their study participants can be attributed to noise, and which are just part of the normal sleep pattern. Thanks to the curfew on scheduled flights between 11 pm and 5 am during the NORAH study, the scientists were able to analyze much more precisely than in earlier studies how the timing of wake-up reactions changes with and without aviation noise. Nonetheless, further studies could contribute towards a better understanding of how often we wake up spontaneously at night without any external influences, and how flexible the body is in adapting its wake-up reactions to noise influences.

With the new "vegetative-motor" method used by NORAH, the focus of the scientists was brought back to the fact that nocturnal overflights can, in many cases, increase the heartbeat of sleepers.

Glossary

You will find further explanations in the glossary at **www.laermstudie.de**.

Wake-up reaction

When a sleeping person changes from a deep sleep into the lightest sleep phase, or wakes up completely, the sleep researchers of the German Aerospace Centre (DLR) speak of a wake-up reaction. Even in a quiet environment, sleepers will experience such a wake-up reaction around 20 to 30 times a night. Usually they cannot remember this in the morning.

Frankfurt Aviation Noise Indices

The Frankfurt Aviation Noise Indices developed by the Airport and Region Forum (ARF) calculate the aviation noise exposure during the day and night in the area around Frankfurt Airport. They take into account the overall landing and take-off situation on the basis of the six busiest months for air traffic. The Frankfurt Aviation Noise Indices are based on dose-effect relationships that were identified within the framework of studies in the Rhine-Main region and at Cologne/Bonn Airport.

Maximum sound level

The physical value which best describes how strongly nocturnal aviation noise impacts on sleep is the maximum sound level of the overflight noise. The annoyance effect overall depends on the height and the frequency of occurring maximum noise levels.

Polysomnography

A polysomnographic investigation registers several physical measurement values during sleep, including the brain activity and eye movements, the heartbeat and the breathing rhythm. This information helps doctors, for example, to identify the causes of sleep disorders.

Sleep lab

In sleep labs scientists can measure and observe the course of a person's sleep and when he changes from one sleep phase to another. Almost all of the investigations carried out in sleep labs use polysomnography.

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RANCH

Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health: Exposure-Effect Relationships and Combined Effects.

Introduction

Previous studies have found associations between exposure to aircraft noise and children's school performance and health. This suggests that children may be a high risk group vulnerable to the effects of noise. However, most studies have not examined exposure-effect relationships nor the effects of combinations of aircraft and road traffic noise. An exposure-effect relationship, that shows increasing effects on health with greater exposure to noise, is an important step in confirming causal associations between noise and child health outcomes.

The RANCH project, the largest study of noise and children's health to date, was designed to examine exposure-effect relationships between aircraft and road traffic noise exposure and school performance, annoyance and blood pressure in 9-10 year old children living around major airports in the Netherlands, Spain and the United Kingdom **(airport field studies)**. The project also included studies of road traffic noise and sleep at home in Sweden **(road traffic field study)** and studies of soundscapes in the UK and Sweden **(soundscapes studies)**. The RANCH project provides a robust evidence base to inform pan-European noise policy based on health effects in children.

Airport Field Studies

Children were selected to take part in these studies on the basis of school noise exposure around Heathrow, Schiphol and Barajas airports. Schools were selected from a wide range of aircraft and road traffic noise exposures to examine exposure-effect relationships for different levels of aircraft noise, road traffic noise and combinations of aircraft and road traffic noise. Children completed tests of reading comprehension, memory and attention in their classrooms. They also completed a questionnaire about their attitudes to noise in the school and at home. Blood pressure measurements were taken in a sub-sample. Parents completed a questionnaire about the family's health and social background. The following table shows the number of schools and children that took part.

RANCH	*No. of Children*	*No. of Schools*	*Child Response Rate*	*Parent Response Rate*
UK	1174	29	87%	82%
Netherlands	762	33	92%	86%
Spain	908	27	88%	72%

Key Findings

- Aircraft noise exposure was related to impaired performance in reading comprehension and recognition memory. Reading age in children exposed to high levels of aircraft noise was delayed by up to 2 months in the UK and by up to 1 month in the Netherlands for a 5 dB change in noise exposure.
- Road traffic noise exposure was unexpectedly related to better performance in recall memory but was not associated with reading comprehension, recognition memory or working memory.
- Both aircraft and road traffic noise exposure were related to annoyance. Annoyance is a stress response to noise exposure implying reduced well-being and quality of life.
- Chronic exposure to aircraft and road traffic noise was not associated with general health status and mental health and inconsistently associated with elevated blood pressure.

Road Traffic Field Study

In the road traffic field study, school children (160 children aged 9-12 years) from four different road traffic noise level areas in Sweden participated in a face to face interview in their home. Each child's parent also completed a questionnaire. Questions were asked about health, sleep quality and disturbance from traffic noise. A sub-sample of these participants (80 children & 80 parents) also took part in a sleep study using wrist actigraphs and sleep logs to evaluate sleep quality.

Key Findings

- Children have better reported sleep quality and a lower number of awakenings than parents. Children and parents reported the same extent of difficulties falling asleep and feeling alert in the morning.
- Children reported more frequent problems with daytime sleepiness in areas with high noise levels. There was a weak association between road traffic noise exposure and reported sleep quality.
- For both children & parents, disturbance from traffic noise and well-being were related to sleep quality.

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Soundscape Studies

Children's and adult's 24 hour acoustic soundscapes were mapped by sound recordings, indoors and outdoors, at homes and schools. A soundscape considers all the sounds in the environment together and is like a landscape of sounds. Two laboratory experiments (UK and Sweden) with children and adults assessed the loudness and pleasantness of the soundscapes. The UK study focused on soundscapes dominated by aircraft and road traffic noise at school, and the Swedish study on soundscapes dominated by road traffic noise at home.

A health evaluation model for children was developed and tested at a pan-European level to identify potential harmful and protective influences on children's health and development. This model included assessing children's opportunities for psychological restoration when living in noise dominated soundscapes. The psychological restoration questionnaire was included in the airport field studies and in the Swedish road traffic noise study.

Key Findings

- Children are as skilled as their parents in assessing the loudness of sounds and in judging the unpleasantness of soundscapes. This supports the validity of annoyance responses in children. Children are as able as adults to evaluate and respond to noise.

- Children from a wide-range of aircraft noise exposures did not differ in their judgements of soundscapes. This means that children respond to noise in the same way regardless of their personal noise exposure.

- Children's psychological restoration combined with adult social support may serve as protective factors for reducing children's self-reported annoyance at school and at home.

Overall Conclusions

On the whole we found similar effects of noise on school performance and annoyance across the Netherlands, Spain and the United Kingdom.

The RANCH results, considered with evidence from previous studies, suggests that aircraft noise has specific causal effects on children's school performance and health. The functions most adversely affected by noise are reading, recognition memory and annoyance. It is not known whether these effects are temporary or permanent.

The results of the RANCH project suggest that road traffic noise is associated with annoyance. There was no evidence that road traffic noise affected reading. The unexpected association between road traffic noise and recall memory needs further investigation.

Opportunities for psychological restoration and restorative environments improve children's well-being and potentially protect against adverse reactions to noise.

Action is recommended at a European level to provide healthy educational environments for children attending high noise exposed schools.

Benefits to Europe and Policy Recommendations

The results of the RANCH project, adding to previous research, provide an evidence base that has implications for European environmental health policy. Our advice is as follows:

1. Since similar effects were found across Europe, guidelines and policies setting the same external aircraft noise limits for children could be applied across Europe.

2. The results from the exposure-effect studies show aircraft noise effects on children's school performance and health within the range of the suggested guidelines for external noise at schools proposed by the World Health Organization.

3. Guidelines and policy should be developed to provide healthy educational environments for children exposed to high noise levels. These include measures to provide restorative and relaxing environments for children.

4. Our results confirm the need to consider noise exposure, with other environmental aspects, when planning new schools. New schools should not be planned or built close to existing airports, where there is excessive noise exposure. Measures should be taken to reduce noise in existing schools, where there is excessive noise exposure.

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Original Contribution

Exposure-Effect Relations between Aircraft and Road Traffic Noise Exposure at School and Reading Comprehension

The RANCH Project

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Transport noise is an increasingly prominent feature of the urban environment, making noise pollution an important environmental public health issue. This paper reports on the 2001–2003 RANCH project, the first cross-national epidemiologic study known to examine exposure-effect relations between aircraft and road traffic noise exposure and reading comprehension. Participants were 2,010 children aged 9–10 years from 89 schools around Amsterdam Schiphol, Madrid Barajas, and London Heathrow airports. Data from the Netherlands, Spain, and the United Kingdom were pooled and analyzed using multilevel modeling. Aircraft noise exposure at school was linearly associated with impaired reading comprehension; the association was maintained after adjustment for socioeconomic variables ($\beta = -0.008$, $p = 0.012$), aircraft noise annoyance, and other cognitive abilities (episodic memory, working memory, and sustained attention). Aircraft noise exposure at home was highly correlated with aircraft noise exposure at school and demonstrated a similar linear association with impaired reading comprehension. Road traffic noise exposure at school was not associated with reading comprehension in either the absence or the presence of aircraft noise ($\beta = 0.003$, $p = 0.509$; $\beta = 0.002$, $p = 0.540$, respectively). Findings were consistent across the three countries, which varied with respect to a range of socioeconomic and environmental variables, thus offering robust evidence of a direct exposure-effect relation between aircraft noise and reading comprehension.

child psychology; cognition; environment and public health; environmental exposure; noise; reading

Abbreviation: dB(A), a measure of sound level in decibels A-weighted to approximate the typical sensitivity of the human ear.

Exposure to transport noise is an increasing and prominent feature of the urban environment. The ubiquitous demand for air and road travel means that more people are being exposed to transport noise, making noise pollution an increasingly important environmental issue for public health. The effect of chronic aircraft noise exposure and road traffic noise exposure on reading comprehension in primary school children is established (1–6), but, to our knowledge, no exposure-effect relations for aircraft noise or road traffic noise and reading comprehension at the individual level have been established. This paper reports findings of the RANCH project (Road traffic and Aircraft Noise Exposure and Children's Cognition and Health), the largest known epidemiologic study undertaken of noise

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exposure and children's cognition and health (7), which examined exposure-effect relations between noise exposure at school and reading comprehension in the Netherlands, Spain, and the United Kingdom.

Most previous studies compared the performance of children exposed to high noise levels with children exposed to low noise levels. While demonstrating an effect of chronic noise exposure on reading, these studies provide limited information in terms of the levels at which the effects of noise on children's reading comprehension begin. Previous studies that examined exposure-effect relations between aircraft noise exposure and reading assessed reading retrospectively from school records (8, 9) and may have confounded chronic noise exposure with acute noise exposure during testing. The RANCH project examined children from schools subjected to a wide range of noise exposures, making it possible to establish exposure-effect curves for aircraft and road traffic noise to examine the lowest observable effect level of noise on reading comprehension.

To our knowledge, this study is the first to be able to make intercountry comparisons of the effect size of aircraft and road traffic noise on reading comprehension. Using the same methodology in each country enabled a large sample size to be achieved by pooling the data from each country and comparing the effect size across countries.

Areas with high levels of environmental noise are often socially deprived, and children from areas of high social deprivation perform poorly on reading comprehension tasks, leading to potential confounding (10). Some studies have demonstrated an effect of environmental noise after adjusting for the influence of socioeconomic status (1), and other studies have not (4–6, 8, 10, 11). However, longitudinal studies (12, 13) have found that a reduction in noise exposure eliminated previously observed noise-related reading deficits, suggesting that socioeconomic status does not confound the relation. This study collected comparable data on socioeconomic status in the Netherlands, Spain, and the United Kingdom to examine whether socioeconomic status confounds the relation between chronic noise exposure and reading comprehension.

The relation between noise exposure and reading comprehension may be mediated by other cognitive abilities important in the development of children's reading ability, such as attention, episodic memory, and working memory. While environmental stressors can have a strong impact on the degree to which information is processed, retained, and recalled (14), a previous study found that attention did not mediate the relation between aircraft noise and reading comprehension (1, 11). The current study collected data on attention, episodic memory, and working memory, using the same nonverbal tests in each country, to examine whether these were intervening factors in the relation between noise exposure and reading comprehension.

The aim of this study was to assess exposure-effect relations of chronic aircraft and road traffic noise with reading comprehension, using data from nationally standardized reading comprehension tasks completed by children aged 9–10 years attending schools exposed to a range of aircraft noise and road traffic noise. It was hypothesized that there would be a linear exposure-effect relation between aircraft and road traffic noise at school and reading comprehension: children exposed to high levels of noise would have poorer reading comprehension than children exposed to low levels of noise, after adjustment for socioeconomic factors. The same relation was hypothesized for aircraft noise exposure at home.

MATERIALS AND METHODS

Sampling and design

Children were selected to take part in this cross-sectional epidemiologic field study on the basis of levels of noise exposure in schools around major airports in three European countries (Schiphol in Amsterdam, the Netherlands; Barajas in Madrid, Spain; and Heathrow in London, United Kingdom). In each country, primary schools around the airport were identified. In Spain and the United Kingdom, all nonstate schools were excluded, which was not possible in the Netherlands. Within each country, schools were matched according to socioeconomic status. In the Netherlands, a neighborhood-level indicator of property value and the percentage of non-Europeans were used to match schools. In Spain and the United Kingdom, schools were matched according to the percentage of children receiving free school meals and speaking the main language at home. Main language spoken at home reflects the number of children who are bilingual—who are taught in English or Spanish and who speak another language at home, for example, Gujerati in the United Kingdom. Children who were recent immigrants and who did not speak the main language of the country proficiently were excluded from the analysis according to a consistent protocol across all countries.

The schools were visited and a noise survey undertaken. Schools were classified in terms of noise exposure on a 4-by-4 grid ranging ordinally from low to high for aircraft noise and low to high for road traffic noise. In each country, two schools were then selected in each of the noise exposure grid cells, and, within schools, mixed-ability classes of boys and girls aged 9–10 years were selected to take part. No children were excluded from the selected classes.

Noise exposure assessment

In all three countries, aircraft noise estimates were based on 16-hour outdoor LAeq contours (LAeq is the "equivalent" average sound level measured by using the A-weighting most sensitive to speech intelligibility frequencies of the human ear), which gave the average continuous equivalent sound level of aircraft noise in an area from 7 a.m. to 11 p.m. for a specified period. The aircraft noise contour data were available nationally and were not derived specifically for this study. In Spain and the United Kingdom, the contours available were from July to September for the years 1999 and 2000, respectively; in the Netherlands, the contours were from October 1999 to November 2000. These contours were used to estimate aircraft noise exposure at school and home for each participant. In the Netherlands, estimates of outdoor road traffic noise were provided by modeled data (15). In the United Kingdom and Spain, estimates of road traffic noise at school were based on a combination of modeling the proximity to motorways, major roads, and minor roads; traffic flow data; and noise measurements taken at the façade of the school building. In all countries, acute noise measurements were taken both inside and outside the classroom during testing. In all analyses, chronic aircraft and road traffic noise were entered as continuous variables in dB(A); dB(A) is a measure of sound level in decibels A-weighted to approximate the typical sensitivity of the human ear.

Outcome and confounding factors assessment

Reading comprehension measures. Reading comprehension was measured by using established, nationally standardized tests. In the United Kingdom, the 86-item Suffolk Reading Scale, level 2 was used, which is suitable for children aged 8 years to 11 years, 11 months (16). In the Netherlands, the 42-item CITO Readability Index for Elementary and Special Education was used (17). This test is designed for children aged 8–12 years. In Spain, the 27-item ECL-2 (Evaluación Comprensión Lectora) was used (18). This test is suitable for children aged 8–13 years. z scores were computed, which enabled comparisons to be made between each country's test.

Potential confounding factors. Comparable measures of potential confounding factors were achieved across countries by using a questionnaire completed by the child during testing and a parent-completed questionnaire. The questionnaires assessed socioeconomic status, parental and child health, and noise-related annoyance. Owing to the large number of potential confounders, variables were retained in the multivariate analysis if analysis of covariance showed a significant relation between the confounder and aircraft noise exposure and/or road traffic noise exposure ($p < 0.05$) (table 1). The confounders retained in the analysis were age, collected from both school records and parents; employment status: whether the parent worked full or part-time; crowding: the number of people per room in the house, defined as more than 1.5 per room in the United Kingdom and Spain and equal to or more than one per room in the Netherlands (the different cutoff points reflect the different official definitions of this concept in each country); home ownership: whether the home was rented or owned/mortgaged; long-standing illness, based on parental reports of the child having attention deficit hyperactivity disorder, asthma/bronchitis, eczema, epilepsy, depression, diabetes, or dyslexia; main language spoken at home, which indicated whether the child spoke the predominant language for the country at home: Dutch, Spanish, or English; classroom glazing, a measure of the glazing (single, double, or triple) of the windows in the child's classroom; mother's educational attainment, measured by using a relative inequality index based on a ranked index of standard qualifications in each country (19); and parental support for schoolwork, assessed by a self-report scale completed by the child.

Mediating cognitive factors. In all three countries, the same established nonverbal tests of cognition were examined (7). Standardized tests were selected, after pilot studies were conducted in each country, that could be group administered, were valid for the population being assessed in terms of age and learning range, and were suitable for children who did not speak the main language at home. Episodic memory (recognition, information recall, and conceptual recall) was measured by using a task from the Child Memory Scale (20) adapted for group administration. Sustained attention was assessed by using the Toulouse Pieron Test adapted for classroom use (21). Working memory was assessed by using a modified version of the Search and Memory Task (22, 23).

Procedure

Group testing was carried out in the classroom, and the cognitive tests were administered as part of a 2-hour testing session conducted in the morning. Written consent was obtained from both parents and the children. Ethical approval was obtained in each country.

Analysis

Data from all countries were pooled and analyzed by using MLwiN multilevel modeling software (24), which took into account the hierarchical nature of the data, with pupils being clustered in schools. Statistical significance was tested by comparing the goodness of fit of different models using a chi-square test of deviance.

Analyses of aircraft noise exposure at school and road traffic noise exposure at school were conducted separately to examine single-exposure effects. For each noise exposure type, two models were run: model 1 (unadjusted) contained only noise exposure (either aircraft or road traffic noise at school); model 2 included both noise exposures and was adjusted for age, gender, country, mother's educational attainment, parental employment status, crowding in the home, parental home ownership, long-standing illness, main language spoken at home, parental support for schoolwork, and classroom glazing type. Further analyses were then conducted, additionally adjusting model 2 for acute noise exposure during testing, dyslexia, hearing impairment, noise annoyance, episodic memory (recognition, conceptual recall, and information recall), working memory, and sustained attention. Hearing impairment was defined as suffering recurrent (earache, ear infection, glue ear, temporary hearing loss) or serious hearing problems (adenoids removed, grommets fitted, long-term hearing loss, hearing aid). Models 1 and 2 were additionally run by substituting aircraft noise exposure at home for aircraft noise exposure at school. To examine combined-exposure effects for aircraft noise, model 2 was additionally adjusted for aircraft noise exposure at school and home, using a measure whereby home aircraft noise exposure for each pupil was centered at his or her school aircraft noise exposure (school noise subtracted from home noise) to assess the effect of the difference between a pupil's home aircraft noise exposure and his or her exposure at school.

The possibility of a curvilinear exposure-effect relation between noise (either aircraft or road traffic) and reading comprehension was investigated by using fractional polynomial models (25). The best-fitting model from a set of two-degree fractional polynomials (of the form $\beta_1$aircraft noise^{p1} + $\beta_2$noise^{p2}, where p_1 and p_2 belong to the set

TABLE 1. School- and pupil-level characteristics* of the RANCH sample, overall and by country, the RANCH project, 2001–2003†

Characteristic	Pooled sample	United Kingdom	The Netherlands	Spain
		School-level data		
No. of schools	89	29	33	27
No. of classes	129	47	34	48
No. of pupils invited	3,207	1,355	824	1,028
No. of pupils participating	2,844	1,174	762	908
No. of pupils and parents participating	2,276	960	658	658
Aircraft noise exposure at school (dB(A)‡)				
Mean (SD‡)	52 (9.7)	52 (9.4)	54 (7.0)	43 (10.7)
Range	30–77	34–68	41–68	30–77
Road traffic noise exposure at school (dB(A))				
Mean (SD)	51 (7.57)	48 (7.25)	53 (8.87)	53 (5.98)
Range	32–71	37–67	32–66	43–71
Classroom glazing (%)				
Single glazing	56.2	58.6	45.5	66.7
Double glazing	39.3	41.4	42.2	33.3
Triple glazing	4.5	0.0	12.1	0.0
		Pupil-level data		
No. of pupils	2,844	1,174	762	908
Response rate (%)				
Child	89	87	92	88
Parent	80	82	86	72
Aircraft noise exposure at home (dB(A))				
Mean (SD)	50 (8.9)	53 (8.9)	49 (7.06)	46 (9.1)
Range	31–76	33–76	34–65	31–73
Age				
Mean	10 years, 6 months	10 years, 3 months	10 years, 5 months	10 years, 11 months
Range	8 years, 10 months–12 years, 10 months	8 years, 10 months–11 years, 11 months	8 years, 10 months–12 years, 10 months	9 years, 5 months–12 years, 4 months
Gender (%)				
Male	47.1	45.1	49.9	47.1
Female	52.9	54.9	50.1	52.9
Parents' employment status (%)				
Not employed	14.9	22.7	7.4	11.1
Employed	85.1	77.3	92.6	88.9
Crowding at home (%)				
Not crowded	78.6	77.3	68.8	90.5
Crowded	21.4	22.7	31.2	9.5
Parents' home ownership (%)				
Not owned	27.7	42.1	18.9	15.4
Owned	72.3	57.9	81.1	84.6
Long-standing illness (%)				
No	75.9	73.6	73.2	81.8
Yes	24.1	26.4	26.8	18.2
Main language spoken at home (%)				
No	11.9	22.0	6.6	2.4
Yes	88.1	78.0	93.4	97.6
Mother's education§ (mean (SD))	0.50 (0.28)	0.50 (0.28)	0.50 (0.28)	0.50 (0.28)
Parental support scale				
Mean (SD)	10.1 (2.0)	10.1 (1.9)	8.8 (1.9)	11.1 (1.5)
Cronbach's α	0.650	0.591	0.582	0.570

* Refer to the Materials and Methods section of the text for a description of the characteristics.

† Some missing values were excluded: age, 5%; gender, <1%; crowding, 7%; home ownership, 6%; long-standing illness, 4%; main language spoken at home, 5%; classroom glazing, 0%; mother's education, 7%; and parental support, 6%.

‡ dB(A), a measure of sound level in decibels A-weighted to approximate the typical sensitivity of the human ear; SD, standard deviation.

§ Measured by using a relative inequality index based on a ranked index of standard qualifications in each country (19); a high score equals lower educational attainment.

TABLE 2. Mean, standard deviation, and range for the reading comprehension, episodic memory, working memory, sustained attention, and annoyance tasks for the RANCH sample, overall and by country, the RANCH project, 2001–2003

Outcome	Pooled sample (n = 2,844)	United Kingdom (n = 1,174)	The Netherlands (n = 762)	Spain (n = 908)
Reading comprehension				
z score				
Mean (SD*)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
Range	−2.36 to 3.07	−2.09 to 2.55	−2.05 to 2.31	−2.36 to 3.07
Original score				
Mean (SD)		51.62 (11.76)	23.12 (7.49)	11.62 (4.32)
Range		6 to 79	7 to 41	1 to 25
Recognition memory				
Mean (SD)	25.08 (2.46)	24.94 (2.64)	25.35 (2.03)	25.04 (2.51)
Range	13 to 30	14 to 30	18 to 30	13 to 30
Information recall				
Mean (SD)	17.68 (5.24)	18.60 (5.42)	16.71 (4.54)	17.33 (5.35)
Range	0 to 30.5	0 to 30.5	1 to 28	0 to 30.5
Conceptual recall				
Mean (SD)	4.86 (1.40)	5.18 (1.41)	4.98 (1.27)	4.37 (1.36)
Range	0 to 9	0 to 9	0.5 to 8	0 to 7
Working memory				
Mean (SD)	16.16 (7.28)	14.82 (7.39)	16.73 (7.06)	17.32 (7.06)
Range	−13 to 35	−13 to 32	−10 to 33	−13 to 35
Sustained attention				
Mean (SD)	101.72 (42.94)	94.96 (44.52)	102.68 (41.80)	109.57 (40.33)
Range	–97 to 222	–97 to 220	–95 to 205	–92 to 222
Aircraft noise annoyance at school†				
Mean (SD)	2.01 (1.02)	2.17 (1.08)	1.96 (0.93)	1.82 (0.98)
Range	1 to 5	1 to 5	1 to 5	1 to 5

* SD, standard deviation.
† Measured on a 5-point Likert scale; a higher score equals a higher annoyance response.

−2, −1, −0.5, 0, 0.5, 1, 2, 3) was chosen; then, the goodness of fit (deviance) of this model was compared with the goodness of fit of a straight-line model to test for departure from a straight-line relation.

RESULTS

Descriptive results

Table 1 illustrates the characteristics of the overall RANCH sample. Participants were 2,844 children aged 9–10 years (Netherlands = 762, Spain = 908, United Kingdom = 1,174) from 89 schools (Netherlands = 33, Spain = 27, United Kingdom = 29). The average age was 10 years, 6 months; 53 percent were female. The overall child response rate was 89 percent and for the parent questionnaire was 80 percent. Participation rates did not vary significantly across noise exposure categories. Completed parent questionnaires were available for 2,276 (80 percent) of the children who participated. There were sociodemographic differences between the countries in terms of parental employment status, home ownership, crowding in the home, and main language spoken at home. These findings reflect sociodemographic differences between the countries and were adjusted for in the analyses. Aircraft noise exposure ranged from 30 to 77 dB(A); mean aircraft noise exposure was lower in Spain than in the United Kingdom or the Netherlands (table 1). Road traffic noise exposure ranged from 32 to 71 dB(A) and was similar across the three countries.

Subjects for whom no values for the potential confounders outlined in table 1 were missing were included in the analysis. The subsample consisted of 88 percent of the overall sample (total N = 2,010; Netherlands = 583, Spain = 572, United Kingdom = 855) and did not differ significantly from the overall sample in terms of sociodemographic characteristics or in terms of reading and cognitive test scores (table 2).

Effects of aircraft noise at school on reading comprehension

Increasing aircraft noise exposure at school was significantly related to poorer reading comprehension (χ^2 = 6.62,

TABLE 3. Multilevel model parameter estimates for aircraft noise and road traffic noise and reading comprehension for the pooled data, the RANCH project, 2001–2003

	Model (N = 2,010)								
	Aircraft noise at school, unadjusted			Road traffic noise at school, unadjusted			Aircraft noise at school and road traffic noise at school, adjusted*		
	β	SE†	p value	β	SE	p value	β	SE	p value
Fixed coefficients									
Intercept	0.404	0.167		−0.168	0.223		−1.364	0.625	0.02
Aircraft noise at school	−0.007	0.003	0.013				−0.008	0.003	0.012
Road traffic noise at school				0.003	0.004	0.454	0.002	0.004	0.54
Spain							1.00		
United Kingdom							0.272	0.082	0.001
The Netherlands							0.320	0.084	<0.001
Age							0.162	0.147	0.271
Female gender							−0.056	0.042	0.18
Parents employed							0.080	0.064	0.21
Crowding at home							−0.073	0.054	0.18
Parents' home ownership							0.205	0.053	<0.001
Mother's education							−0.713	0.077	<0.001
Long-standing illness							−0.147	0.004	0.003
Main language spoken at home							0.183	0.076	0.016
Parental support							0.084	0.011	<0.001
Classroom glazing							0.001	0.027	0.95
Random parameters									
Level 2: school	0.042	0.013		0.049	0.014		0.023	0.010	
Level 1: pupil	0.951	0.030		0.950	0.030		0.865	0.279	

* The adjusted models were evaluated against a model with the noise source excluded. Aircraft noise adjusted χ^2 = 6.62, df = 1, p = 0.012; road traffic noise adjusted χ^2 = 0.37, df = 1, p = 0.54.

† SE, standard error.

df = 1, p = 0.012; table 3). In the adjusted model, as noise increased by 5 dB(A), performance on the reading test (measured by z scores) decreased by −0.040 marks for the overall sample. Children scored lower on the reading test if they had a mother with low educational attainment or if they had a long-standing illness; they scored higher if their parents were homeowners, if the children spoke the main language of the country, and if they perceived a high level of parental support for schoolwork. The effect of aircraft noise exposure on reading comprehension remained when the model was further adjusted for dyslexia, hearing impairment, and acute noise during testing, as well as for working memory, sustained attention, and episodic memory (conceptual recall and information recall) (table 4); the significance of the effect was borderline after adjustment for recognition memory (p = 0.062) and aircraft noise annoyance (p = 0.05).

In all three countries, the same inverse relation between aircraft noise exposure at school and reading comprehension was found (table 5, test of heterogeneity p = 0.9). In the Netherlands and Spain, a 20-dB(A) increase in aircraft noise was associated with a decrement of one eighth of a standard deviation on the reading test; in the United Kingdom, the decrement was one fifth of a standard deviation. The size of the effect did not differ for high and low socioeconomic position. In terms of reading age, when the national data relating to the reading comprehension tests were used (16, 17), one eighth of a standard deviation was equivalent to an 8-month difference in reading age in the United Kingdom and a 4-month difference in reading age in the Netherlands. No comparative national data were available for the Spanish ECL-2 test (18).

Figure 1 shows reading comprehension adjusted for age, gender, and country by 5-dB(A) bands of aircraft noise. There was no significant departure from linearity when we compared straight-line fit with best-fitting fractional polynomial curve (p = 0.99).

Effects of aircraft noise exposure at home on reading comprehension

Aircraft noise exposure at home was highly correlated with aircraft noise exposure at school (Netherlands: r = 0.93, Spain: r = 0.85, United Kingdom: r = 0.91) (figure 2). Increasing aircraft noise exposure at home was significantly and linearly related to poorer reading comprehension (χ^2 = 5.88, df =1, p = 0.015). There was no additional effect of

TABLE 4. Multilevel model parameter estimates for aircraft noise at school on reading comprehension, additionally adjusted for memory outcomes and aircraft noise annoyance, the RANCH project, 2001–2003

	No.	Aircraft noise at school, adjusted		
		β	SE*	*p* value
Adjusted†	2,010	−0.008	0.003	0.012
Adjusted† + working memory	1,920	−0.006	0.002	0.015
Adjusted† + recognition memory	1,978	−0.005	0.002	0.062
Adjusted† + conceptual recall	1,953	−0.006	0.002	0.018
Adjusted† + information recall	1,952	−0.006	0.002	0.028
Adjusted† + sustained attention	1,918	−0.008	0.002	0.003
Adjusted† + aircraft noise annoyance	1,926	−0.006	0.003	0.05

* SE, standard error.

† Adjusted for age, gender, country, mother's education, employment status, crowding at home, home ownership, long-standing illness, main language spoken at home, parental support, classroom glazing, and road traffic noise exposure.

home aircraft noise exposure after adjustment for aircraft noise exposure at school ($\chi^2 = 0.24$, df = 1, $p = 0.625$) (table 6).

Effects of road traffic noise at school on reading comprehension

Chronic road traffic noise exposure at school had no significant effect on reading comprehension either before ($\chi^2 = 0.44$, df = 1, $p = 0.51$; model not shown) or after ($\chi^2 = 0.37$, df = 1, $p = 0.54$; table 3) adjustment for aircraft noise exposure at school. In addition, there was no significant departure from linearity for reading comprehension adjusted for age, gender, and country ($p = 0.90$ for comparison of straight-line fit with best-fitting fractional polynomial curve).

DISCUSSION

The aim of this study was to compare performance on a standardized reading comprehension task for children aged 9–10 years attending schools exposed to varying levels of aircraft noise and road traffic noise around major airports in three European countries. There were three main findings. Firstly, a linear exposure-effect relation was found between aircraft noise exposure at school and impaired reading comprehension, with a similar effect being observed in all three countries. Secondly, the effect of aircraft noise on reading comprehension could not be accounted for by sociodemographic variables, acute noise during testing, aircraft noise annoyance, episodic memory, working memory, or sustained attention. Thirdly, there was no evidence of a relation between road traffic noise at school and reading comprehension. These results raise concerns regarding the effect of chronic aircraft noise exposure on children's reading ability.

This is the first study known to establish that the exposure-effect relation between aircraft noise and reading comprehension is linear. In all three countries, a negative relation was found between aircraft noise exposure at school and reading comprehension. These results are consistent with previous studies (1, 3) but less consistent with the West London Schools and the Munich studies, which reported an effect for only the most difficult items on a standardized reading test (10, 12). The current study utilized an exposure-effect measure of aircraft noise exposure, examining a wider range of noise exposures, while the previous

TABLE 5. Effect size of aircraft noise and road traffic noise on reading comprehension for the pooled data and for each country, the RANCH project, 2001–2003

	β	SE*	95% CI*	*p* value from χ^2†
Aircraft noise at school				
Pooled estimate‡	−0.008	0.003	−0.014, −0.002	0.012
United Kingdom§	−0.009	0.005	−0.019, 0.001	
The Netherlands§	−0.006	0.007	−0.020, 0.008	
Spain§	−0.006	0.005	−0.016, 0.004	
Road traffic noise at school				
Pooled estimate‡	0.002	0.004	−0.005, 0.009	0.54
United Kingdom§	−0.003	0.006	−0.014, 0.009	
The Netherlands§	0.004	0.005	−0.007, 0.014	
Spain§	0.008	0.008	−0.009, 0.024	

* SE, standard error; CI, confidence interval.

† Test of heterogeneity: aircraft noise $p = 0.9$, road traffic noise $p = 0.10$.

‡ Adjusted for age, gender, country, mother's education, employment status, crowding, home ownership, long-standing illness, main language spoken at home, parental support, classroom glazing, and road traffic noise exposure.

§ Adjusted for all factors except country given in the previous footnote.

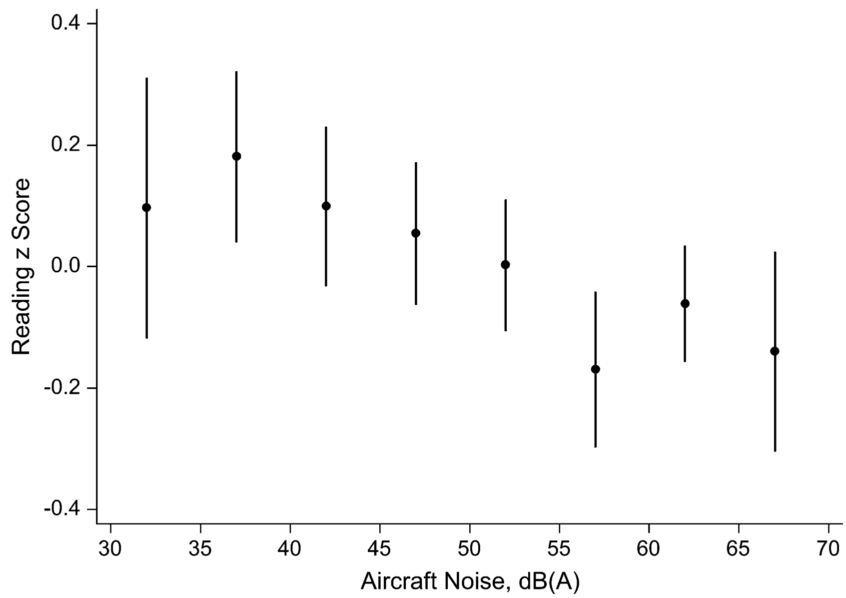

FIGURE 1. Adjusted mean reading *z* scores and 95% confidence intervals for 5-dB(A) bands of aircraft noise at school (adjusted for age, gender, and country), the RANCH project, 2001–2003. dB(A), a measure of sound level in decibels A-weighted to approximate the typical sensitivity of the human ear.

studies categorized children into low and high aircraft noise exposure, thus limiting the power of the studies.

The magnitude of the effect of aircraft noise on reading comprehension did not differ among countries. In the Netherlands and Spain, a 20-dB(A) increase in aircraft noise was associated with a decrement of one eighth of a standard deviation on the reading test; in the United Kingdom, the decrement was one fifth of a standard deviation. Although the magnitude of the effect of aircraft noise on reading is small, the consequences of long-term exposure on reading comprehension remain unknown. It is possible that children could be exposed to aircraft noise for many of their childhood years; in the United Kingdom and Spain, high environmental noise exposure is often found in socially deprived

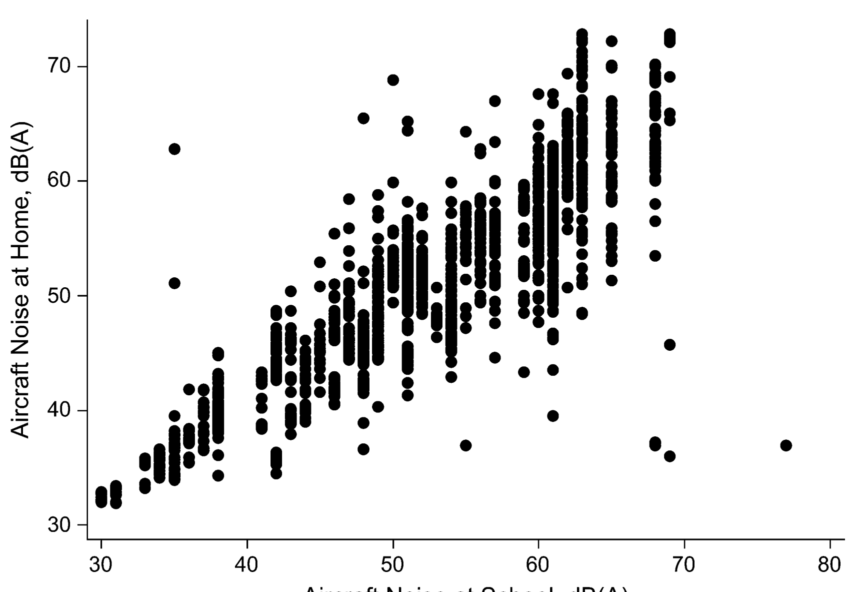

FIGURE 2. Association between aircraft noise exposure at school and aircraft noise exposure at home for the pooled data from the RANCH project, 2001–2003. dB(A), a measure of sound level in decibels A-weighted to approximate the typical sensitivity of the human ear.

TABLE 6. Multilevel model parameter estimates for aircraft noise at home and school and road traffic noise at school on reading comprehension for the pooled data*

	Model					
	Aircraft noise at home and road traffic noise at school, adjusted†			Aircraft noise at home and school, and road traffic noise at school, adjusted†		
	β	SE‡	*p* value	β	SE	*p* value
Aircraft noise at home	−0.008	0.003	0.015	−0.003	0.006	0.6
Aircraft noise at school				−0.009	0.003	0.008
Road traffic noise at school	0.002	0.004	0.50	0.002	0.004	0.5

* The adjusted models were evaluated against a model with the noise source excluded. Aircraft noise at home adjusted $\chi^2 = 5.88$, df = 1, $p = 0.015$; aircraft noise at home and school adjusted $\chi^2 = 0.24$, df = 1, $p = 0.625$.

† Both models were additionally adjusted for country, age, gender, mother's education, employment status, crowding, home ownership, long-standing illness, main language spoken at home, parental support, and classroom glazing.

‡ SE, standard error.

areas, where social mobility is low. While the Munich study (12) demonstrated that the effects of aircraft noise exposure on reading comprehension are reversible if the noise ceases, studies have yet to examine the long-term developmental consequences of exposure that persists throughout a child's education. Demand for air travel continues to increase, and further knowledge about cumulative exposure would inform intervention strategies and policy decisions.

In some previous studies, the association between noise exposure and reading has been confounded by socioeconomic status (10). Our study examined a comprehensive set of individual-level socioeconomic status variables in all three countries and found that the relation between aircraft noise exposure and reading comprehension could not be accounted for by socioeconomic status or other individual-level factors, such as long-standing illness and parental support for schoolwork. The United Kingdom sample, despite being of lower socioeconomic status, responded to noise exposure similarly to the more affluent Dutch and Spanish samples, suggesting that socioeconomic factors do not explain the effect of aircraft noise on reading.

The relation between aircraft noise exposure and reading comprehension was not mediated by sustained attention, working memory, or episodic memory: the significance of the effect was borderline after adjustment for the recognition measure of episodic memory but remained after adjustment for conceptual recall and information recall. There was limited support for a finding that the relation was not mediated by noise annoyance (1). These results, together with previous findings (1, 12), suggest that noise may either directly affect reading comprehension or be accounted for by other mechanisms. It is postulated that noise restricts attention to central cues during complex language-related tasks (4, 26, 27). The current research has not examined the psycholinguistic mechanisms that may underlie the effect, and further research on psycholinguistic mechanisms will inform the design of educational and environmental interventions for children in schools exposed to high levels of aircraft noise.

Aircraft noise exposure at school and home independently demonstrated a comparable association with reading comprehension. There was substantial colinearity between school and home aircraft noise exposure, which has been demonstrated previously (10), making it difficult to assess whether exposure at school or home differentially affected reading comprehension. After centering home aircraft noise exposure on school aircraft noise exposure (subtracting school exposure from home exposure), we demonstrated that there was no additional effect of home aircraft noise exposure after adjustment for aircraft noise exposure at school. It was not possible to fully establish the relative contribution of home and school exposure over a full 24-hour period to cognitive deficits in children in this study, and this is an important challenge for future research.

We found no significant effect of road traffic noise exposure on reading comprehension, which refuted our hypothesis and is inconsistent with previous studies (4, 5). However, the levels of road traffic noise in this study were not as high as those in some previous studies. In the Cohen et al. study (4), noise levels were typically above 80 dB(A) based on the mode of 5-minute measures at home. In this study, the annual equivalent levels ranged from 32 to 71 dB(A) at school. It is also possible that exposure to road traffic noise at home may influence reading either in its own right or by interacting with exposure at school. Unfortunately, national data on road traffic noise exposure at home were not available. No definite conclusion about the effect of road traffic noise exposure can be drawn until the results of the current study are replicated and the effect of home road traffic noise exposure is investigated.

Why should there be an effect for aircraft but not road traffic noise? Aircraft noise is more intense and less predictable than road traffic noise. The transient nature of aircraft flyovers, which have high short-term noise levels, may disrupt children's concentration and distract them from learning tasks, while the constant nature of road traffic noise may allow children to habituate and not be distracted. Banbury et al. (28) suggest that sound that varies appreciably over time will impair cognitive performance, whereas sound that does not is associated with little or no impairment. Aircraft noise exposure may also cause higher arousal levels than road traffic noise, and high arousal will interfere with performance tasks such as reading comprehension (29). A further explanation for the lack of an effect for road traffic noise exposure is that differences between countries in estimating road traffic noise exposure may have resulted in a differential quality in exposure assessment. Traffic flow may have been underestimated; exposure misclassification may also have occurred because classrooms were at varying distances from the façade of the school building.

Our study has limitations: reading measures not being exactly equivalent across countries, reliance on external measures of noise exposure, and lack of data about noise exposure over the 24 hours. However, this study represents an improvement on previous studies because of its size, in terms of both number of participants and schools. To our knowledge, it is the largest study of noise exposure and cognition in children and is the only study able to compare the reading effect size in different countries across a wide range of noise exposures. Application of multilevel modeling enabled the effect of both school-level and individual-level variables to be examined. A further strength of the study is the comprehensive number of individual-level socioeconomic variables that were examined.

In conclusion, our results suggest that aircraft noise exposure is linearly associated with impaired reading comprehension. No association was found between road traffic noise exposure and reading comprehension, either in the absence or the presence of aircraft noise. However, we could not rule out an effect at higher levels of road traffic noise. The consistent findings across the three countries, with substantial differences regarding a range of socioeconomic and environmental variables, offer robust evidence of an exposure-effect relation between aircraft noise and reading comprehension.

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13 Southwood Road

Ramsgate

CT11 0AA

15th February 2019

Reference 20014413

My name is Susan Kennedy and I am a Ramsgate resident. I'm a founding member of the No Night Flights group and a Ramsgate Town Councillor. I'm an educationalist and spent many years teaching in secondary schools. For the last 12 years I have been working in the NHS, specifically in medical education. My interest, particularly, in this submission is focused on the health and education aspects highlighted by the applicant's proposal.

I am opposed to the proposal on the grounds that the noise resulting from the plans would be seriously detrimental to the health, wellbeing, educational and life prospects of the children and adults within our town.

All references within this submission are supported by the documents to which they refer, provided as an appendix.

Aviation Noise

In July 2016 the European Commission published a summary of a report looking at how living with aircraft noise affects wellbeing. It found that:

Living within a daytime aircraft noise path (with noise at or above 55 decibels) … was negatively associated with all measures of subjective wellbeing: lower life satisfaction, lower sense of worthwhile, lower happiness, lower positive affect balance, and increased anxiety. The authors found consistently negative and significant results across all five variables. [1]

In a study produced by Queen Mary University of London for the Airports Commission, the conclusion was that:

> *The health effects of environmental noise are diverse, serious, and because of widespread exposure, very prevalent … For populations around airports, aircraft noise exposure can be chronic. Evidence is increasing to support preventive measures such as insulation, policy, guidelines, & limit values. Efforts to reduce exposure should primarily reduce annoyance, improve learning environments for children, and lower the prevalence of cardiovascular risk factors and cardiovascular disease.*[2]

"The World Health Organisation (WHO) have estimated sleep disturbance to be the **most adverse** non-auditory effect of environmental noise exposure (Basner et al., 2014; WHO, 2011). Undisturbed sleep of a sufficient number of hours is needed for alertness and performance during the day, for quality of life, and for health (Basner et al., 2014). Humans exposed to sound whilst asleep still have physiological reactions to the noise which do not adapt over time including changes in breathing, body movements, heart rate, as well as awakenings (Basner et al., 2014). The elderly, shift-workers,

[1] "How does living with aircraft noise affect wellbeing? A study of UK airports", Science for Environment Policy, Issue 462, 8 July 2016; based on: Lawton, R. and Fujiwara, D. (2016). Living with aircraft noise: Airport proximity, aviation noise and subjective wellbeing in England. Transportation Research Part D: Transport and Environment, 42: 104– 118. DOI: 10.1016/j.trd. 2015.11.002

[2] Queen Mary University of London, for the Airports Commission, Aircraft noise effects on health, May 2015, p27

children and those with poor health are thought to be at risk for sleep disturbance by noise (Muzet, 2007)."[3]

WHO is clear on aircraft noise. The Europe Night Noise Guidelines (WHO, 2009) advise that the target for noise at night should be 40dB $L_{night,\ outside,}$ on the basis that this is the level which should ensure protection of the public at large but, most specifically, vulnerable groups such as children, the elderly and those suffering from chronic health conditions. WHO suggests that moving incrementally towards such targets would see countries enforcing levels of 55dB $L_{night,\ outside}$.

There is ongoing study into people's perceptions of noise and the levels of noise at which quality of life (and health) is significantly adversely impacted. The Attitudes to Noise from Aviation Sources in England (ANASE) in 2007 concluded that:

> *"levels of annoyance reported by respondents increased with the sound level; people were concerned about noise at even low levels and particularly at night*"[4]

Subsequent studies have been critical of this 'old' data, however, and the focus on 'the onset of significant annoyance ' at 57 LAeq and the 'belief that communities below this noise exposure threshold are relatively unaffected by aircraft noise'.[5] It is increasingly clear that both health and wellbeing are significantly adversely impacted at 40-45dB.

Historic data and the lived experience of residents of Ramsgate show that we are talking about far, far higher levels of noise.

Examples below and full table attached

Location	direction	airline	date	runway	aircraft	registration	lmax	db
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	01/06/2003 10:16:00	28	DC86 9	GMKK	96.6	89.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	02/06/2003 11:44:00	28	B742 9	GMKP	99.6	93.5
Clarendon House Grammar School Monitor No.2	Departure	Iceland	02/06/2003 11:57:00	28	B742	TFARF	97	90.8
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	04/06/2003 13:30:00	28	B742 9	GMKQ	101	94.6
Clarendon House Grammar School Monitor No.2	Departure	Iceland	04/06/2003 13:44:00	28	B742	TFARF	98.2	92.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	06/06/2003 14:06:00	28	B742 9	GMKL	98.6	92.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	09/06/2003 10:37:00	28	B742 9	GMKL	97.3	90.8
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	10/06/2003 00:55:00	28	B742 9	GMKP	97.6	91.2
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	10/06/2003 11:36:00	28	B742 9	GMKQ	102	96.2
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	11/06/2003 07:24:00	28	DC86 9	GMKK	97.4	89.3
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	11/06/2003 10:43:00	28	B742 9	GMKL	98.5	92.3
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	13/06/2003 00:12:00	28	B742 9	GMKQ	101	96.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	19/06/2003 00:09:00	28	B742 9	GMKL	101	95.1
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	19/06/2003 10:35:00	28	DC86 9	GMKK	97.3	89.8
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	20/06/2003 11:54:00	28	B742 9	GMKP	98.5	92.4
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	27/06/2003 11:50:00	28	B742 9	GMKP	98.5	92.2
Clarendon House Grammar School Monitor No.2	Departure	MKA MK Airlines Ltd	30/06/2003 00:44:00	28	B742 9	GMKL	98.2	92.2
St Nicholas Roundabout Monitor No. 1	Departure	BEC ???	01/12/2003 08:27:00	10	AN12	UN11373	87.7	77.3
St Nicholas Roundabout Monitor No. 1	Departure	BEC ???	01/12/2003 08:27:00	10	AN12	UN11373	87.7	77.3
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	01/12/2003 11:59:00	10	DC86	9GMKG	87.8	76.2
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	01/12/2003 11:59:00	10	DC86	9GMKG	87.8	76.2
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	02/12/2003 14:53:00	10	DC86	9GMKO	89.2	76.5
St Nicholas Roundabout Monitor No. 1	Departure	MKA MK Airlines Ltd	02/12/2003 14:53:00	10	DC86	9GMKO	89.2	76.5

[3] Queen Mary University of London, for the Airports Commission, Aircraft noise effects on health, May 2015, p5
[4] John Bates Services etc. for the DfT, ANASE: Attitudes to Noise from Aviation Sources in England, October 2007
[5] Ian Flindell & Associates and MVA Consultancy for 2M Group, Understanding UK Community Annoyance with Aircraft Noise: ANASE Update Study, September 2013,

Location	directi	airline	date	runwa	aircraft	registrati	lm	db
Unknown	Arrivals	MKA MK Airlines	05/01/2008 21:22:00	28	B742	GMKHA	99.4	91.8
Unknown	Arrivals	MKA MK Airlines	13/01/2008 14:41:00	28	B742	9GMKM	97.7	91.8
Unknown	Arrivals	MKA MK Airlines	18/01/2008 15:51:00	28	B742	TFARW	100	93.4
Unknown	Arrivals	MKA MK Airlines	27/01/2008 09:11:00	28	B742	GMKFA	98.3	91
Unknown	Arrivals	MKA MK Airlines	29/01/2008 15:49:00	28	B742	GMKGA	99.5	96.2
Unknown	Departure	MKA MK Airlines	29/01/2008 20:27:00	10	B742	GMKGA	103	96.3
Unknown	Arrivals	MKA MK Airlines	30/01/2008 13:13:00	28	B742	GMKHA	99.6	91.5
Unknown	Arrivals	MKA MK Airlines	05/02/2008 13:26:00	28	B742	GMKCA	99.1	91.5
Unknown	Arrivals	MKA MK Airlines	07/02/2008 14:07:00	28	B742	GMKGA	98.1	94.7
Unknown	Departure	AIN African International Airways	18/02/2008 22:19:00		DC85	ZSOSI	99.7	91.1
Unknown	Departure	AIN African International Airways	19/02/2008 18:39:00	10	DC86	ZSOSI	101	91.2
Unknown	Arrivals	MKA MK Airlines	21/02/2008 10:40:00	28	B742	GMKDA	99.1	92.4
Unknown	Departure	MKA MK Airlines	24/02/2008 00:47:00	10	B742	GMKBA	98.8	93.6
Unknown	Arrivals	MKA MK Airlines	24/02/2008 08:10:00	28	B742	GMKBA	99	92.4
Unknown	Arrivals	MKA MK Airlines	26/02/2008 17:47:00	28	B742	GMKHA	98.9	91.9
Unknown	Arrivals	CLX Cargolux Airlines	11/03/2008 14:28:00	28	B744	LXPCV	99	91.5
Unknown	Arrivals	MKA MK Airlines	14/03/2008 18:25:00	28	B742	N704CK	98.6	91.9
Unknown	Arrivals	MKA MK Airlines	18/03/2008 11:23:00	28	B742	GMKCA	98.1	92.2
Unknown	Departure	MKA MK Airlines	18/03/2008 15:48:00	28	B742	GMKCA	99.1	91.1
Unknown	Arrivals	MKA MK Airlines	21/03/2008 00:18:00		B742	GMKBA	106	106.5

Noise and health and wellbeing

The Planning Inspectorate and, even more importantly, residents actually have no way of knowing exactly what the potential noise impacts would be if RSP were successful in their application. This is because 'exact' operations that consider airspace options, flight paths, operating principles are not to be formalised through an Airspace Change Proposal (ACP) until after a DCO is granted. Similarly, in absence of an evidenced business plan with clear expressions of interest or solid indications about likely traffic and aircraft types, there is no way of knowing which aircraft would be flying over our heads. Even in terms of the numbers of ATMs per annum, RSP have played fast and loose with these figures over the years and through different consultations to their final application. With little way of knowing whether Ramsgate and beyond would be subjected to 17,000 or 83,000 ATMs, or anything in between, it is impossible do know what levels of noise could be expected. And yet RSP have presented a noise mitigation plan. Without supporting detail and evidence, this mitigation plan is scarcely worth the paper it is written on.

RSP's application suggests that the number of residents likely to be affected by their proposal (experiencing noise levels of 80dBs LAS) is around 20,000. The actual figure, based on historic data suggests much closer to 50,000 people. The sample noise monitoring tables provided above are from a larger set of monitoring data provided regularly at the Kent International Airport Consultative Committee and available in that committee's minutes. The noise monitors were positioned strategically at both east and west ends of the runway and were properly maintained. RSP should have provided the data recorded by these monitors and submitted to KIACC and I regard it as essential that they be required to do so as part of this examination stage of the process.

The Bickerdike Allen and Partners Report (2010)[6] and the Bureau Veritas Report (2010) which considered in detail noise impact, similarly, need to be submitted and interrogated by way of comparison to RSP's noise assessments and impact analyses. Both reports would suggest that RSP have failed to properly assess levels of noise, extent of noise impact and numbers of people impacted. A typical sleight of hand of RSP's is to present their 'numbers impacted' in terms of households rather than actual people. Given that it is actual people who will be adversely affected and that it is the numbers of people impacted needed in order to correctly and fully assess impact, this seems deliberate and unhelpful.

[6] Reading of Bickerdike Allen and Partners should be read with reference to more recent studies about the levels of noise at which noise significantly impacts, as cited previously (work by Ian Flindell and Associates). Similarly, the Bureau Veritas Report suggests that noise levels are understated by BAP.

What is clear is that RSP has deliberately underestimated and therefore downplayed the levels of noise and the impact of noise. They have chosen not to undertake serious analysis and use of the historic noise data that is available in order to assess impact.

Residents are naturally concerned that in presenting this application and noise plan to inspectors analysing the impact of a new airport, inspectors with little to no knowledge, one might presume, of the previous airport, RSP hopes to persuade in terms of their underestimations. Residents themselves know only too well the regular flight paths taken both day and night, the levels of noise, the impact of noise and this lived experience, this knowledge, is borne out by recorded levels of noise, and recorded complaints about noise, during the years when Manston operated. It should be noted that during the 15 years of its commercial life, Manston did not have night flights and those that were experienced were delayed flights. This points to their irregularity and lack of frequency and yet their impact was sufficient to warrant complaints and for residents to recall them with horror. Similarly, one should note the small scale of operations during the daytime. Most residents were insufficiently disturbed or alarmed by two or three flights a day. Given the noise of those daytime flights, an application proposing flights every 20-30 minutes, or even more is one that residents will resist given they can set this against previous lived experience and can anticipate the exponentially worse impact on their lives, health and wellbeing.

In their application, RSP state at 15.8.8 that there is a probability of 'one additional awakening', at most, 'each of three nights on average' and sets this against 'typical spontaneous awakenings at a rate of around 24 a night'. To place typical spontaneous awakenings against any awakening caused by excessive aircraft noise suggests such casual disregard for people as to be breath-taking. It also neglects to contextualise any awakenings through careful analysis of the significant and growing body of research on sleep, sleep disruption, noise impact events and, in particular, that relating to the impact of aircraft noise on populations, in general, and on specific demographic groups. Unfortunately, this disregard of a substantial evidence base is characteristic of the application, as a whole.

RSP's proposal must be properly interrogated in terms of its noise modelling and its noise mitigation plans for any robust consideration of the significantly adverse impact on people's health to be undertaken during this examination process. RSP should be obliged to furnish the inspectorate with proper comparative and historic data.

Impact of aviation noise

Children

Uninterrupted sleep over a minimum of 8 hours is vital for children's growth and, in particular, their cognitive development. Chronic and consistent aircraft noise exposure in children has been demonstrated to be associated with impairment of both reading and long-term memory.

The Munich Study[7] studied the effects of chronic noise and psychological stress on children living near Munich International Airport. This study was also able to investigate the impact on children living near the airport once the airport was relocated away from the study area and on those children who were newly living next to the relocated airport.

> *'Two of the cognitive tasks, recall and language mastery, showed the doubly replicated aircraft noise effect of disappearing when the old airport was closed down and coming forth when the new airport started to operate. This is a very strong empirical foundation for the conclusion*

[7] The Munich Airport Noise Study-Effects of Chronic Aircraft Noise on Children's Perception and Cognition, Hygge, S, Evans G W, Bullinger, M, InterNoise2000, 2000

> *that cognitive tasks requiring central language processing are particularly sensitive to noise*.' [8]

> In the Munich Study "*The authors concluded that in young children chronic noise exposure appeared to cause increased psychological stress, as measured by cardiovascular, neuroendocrine and affective indicators and that these effects occur even among children who suffer no detectable hearing damage while living in the immediate vicinity of an airport*."[9]

The RANCH project[10] examined relationships between aircraft noise exposure and school performance, annoyance and blood pressure in children aged nine to ten in the Netherlands, Spain and the UK. For the UK sample of the RANCH study, night noise contour information was linked to the children's home and related to sleep disturbance and cognitive performance.

> *"The RANCH results, considered with evidence from previous studies, suggests that aircraft noise has specific causal effectives on children's school performance and health. The functions adversely affected by noise are reading, recognition memory and annoyance. It is not known whether these effects are temporary or permanent.*[11]

Results from both the Munich and RANCH studies suggest that night aircraft noise exposure does not appear to *add* (our italics) any cognitive performance decrement to the cognitive decrement already induced by a child's exposure to daytime aircraft noise. In other words, aircraft noise for developing children is **equally bad both day and night**.[12]

> *"Stansfeld et al (2010) also examined the effect of night-time aircraft noise exposure on the cognitive performance of children. This analysis was also an extension of the RANCH study, and the Munich study in which 330 children were assessed on their cognitive performance in three waves, each a year apart, before and after the switch over of airports. Aircraft noise exposure and self-reported sleep quality measures were analysed across airports to examine whether changes in night-time noise exposure had any impact on reported sleep quality, and if this was then reflected in the pattern of change in cognitive performance. In the Munich study, analysis of sleep quality questions showed no evidence of interactions between airport, noise and measurement wave, which suggests that poor sleep quality does not mediate the association between noise exposure and cognition. In the RANCH study, there was no evidence to suggest that night noise had any additional effect to daytime noise exposure. The authors explain that this investigation utilised secondary data and therefore was not specifically designed to investigate night time aircraft noise exposure on cognitive performance in children, but the results from both studies suggest that night time aircraft nose exposure does not appear to add any further deleterious effect to the cognitive performance decrement induced by daytime noise alone. They recommend that future research should be focussed around the school, for the protection of children against the effects of aircraft noise exposure on performance."* [13]

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[8] The Munich Airport Noise Study-Effects of Chronic Aircraft Noise on Children's Perception and Cognition, Hygge, S, Evans G W, Bullinger, M, InterNoise2000, 2000, p3

[9] ERCD Report 0908 Aircraft Noise and Children's Learning, Civil Aviation Authority, 2010 – page 10

[10] Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health: Exposure-Effect Relationships and Combined Effects (RANCH Study), European Community funded, Queen Mary, University of London, Stockholm University, Sweden, Goteborg University, Sweden, National Institute of Public Health and the Environment, The Netherlands, Instituto de Acustica, Madrid, Spain, American Journal of Epidemiology, 2005

[11] RANCH Study – page 2

[12] Night-time aircraft noise exposure and children's cognitive performance, Stansfield S, Hygge S, Clark C, Alfred T, 2010 - Abstract

[13] ERCD Report 0908 Aircraft Noise and Children's Learning, Civil Aviation Authority, 2010 – page 32

More up-to-date even than the Munich and RANCH studies is NORAH, the Noise-related Annoyance, Cognition and Health noise impact study. This has been, to date, the most extensive study internationally on the effects of noise from aviation on the health and quality of life of the population.

> *"Aviation noise affects children not only in school. It has effects on their whole life and their wellbeing."* [14]
>
> *'In areas with high exposure to aviation noise, primary school children learn to read more slowly than children in quiet areas.'*[15]
>
> *'Teachers from areas with relatively high aviation noise exposure reported unanimously that the noise causes considerable disturbances to lessons. More than one third of the children from these schools are sometimes unable to hear the teacher properly due to aviation noise.'*[16]
>
> *'Ten percent of the parents in areas with relatively high noise exposure state that their children are currently taking prescribed medication. In the residential areas with medium exposure it was only four percent, and in the regions with low exposure just under six percent.'*[17]
>
> *'In areas with relatively high noise exposure, 14 percent answered "yes" to the question: "Has a doctor ever diagnosed a language or speech disorder in your child?" In areas with low noise exposure, only 10 percent gave this answer, in the residential areas with medium exposure it was 8 percent. These results are statistically unequivocal*.'[18]

The full NORAH Report is attached but the message is clear. Every year, more and more research is gathered which confirms the significantly negative impact of aviation noise on health. Thanet's children deserve more. Much more. Thanet falls into the most deprived decile in Kent where 66% of children do not achieve 5 good GCSEs compared to 23% in the most affluent decile. [19]

Summarising some of their conclusions, the authors wrote:

> *'This review has aimed to describe the main contributions in the field of aircraft noise and cognitive ability in children. The results are not completely in agreement, but there is evidence to suggest that chronic aircraft noise has a deleterious effect on memory, sustained attention, reading comprehension and reading ability. Early studies highlighted that aircraft noise was also implicated in children from noisy areas having a higher degree of helplessness i.e. were more likely to give up on difficult tasks than those children in quieter areas. This motivational decrement was reported in various studies, and it was suggested that this should be an area for future research over a longitudinal study protocol.'*[20]

With educationalists the world over focusing on 'grit' and 'resilience', the suggestion here that aviation noise impacts negatively on children's abilities to concentrate, to stick at activities, to give up, is a significant one. In an area like Thanet, where confounding factors such as health inequalities, poverty, single-parent households, relative lack of opportunity etc make life more difficult for local children that in other area of the county and country, there is an even more compelling case to ensure that additional adverse factors are not applied to the lives of our children.

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[14] NORAH, Knowledge No 1, Child Study: Effects of aviation noise on children, p6
[15] NORAH, Knowledge No 4, p2
[16] NORAH, Knowledge No 4, p2
[17] NORAH, Knowledge No 4, p10
[18] NORAH, Knowledge No 4, p12
[19] Mind the Cap:Health Inequalities Action Plan for Kent Analytical Report, Kent Public Health Observatory, 2016
[20] ERCD Report 0908, Aircraft Noise and Children's Learning, p18

The RANCH research team recommended that new schools should not be built close to existing airports. **It follows that new airports should not be built close to existing schools**. Schools in Ramsgate that are under the flight path are:

- Manston School House Nursery
- Chatham and Clarendon Grammar School
- The Elms Nursery School
- Priory County Infant School
- Fledglings Nursery School
- Ellington CP School
- Christchurch Church Primary School

As indicated from the screenshot below taken from RSP's documentation, *'significant adverse effects'* can be expected for these schools. The effects include disruption, disturbance or interference with tasks by the users of the building. The 'users' of these buildings are children and teachers. The 'tasks' that will be interfered with are learning activities.

*reduction from Year 2 due to phase out of Boeing 767 aircraft in the fleet

Permanent noise impacts at sensitive non-residential properties

12.9.57 **Table 12.26** presents predicted daytime noise levels resulting from the Proposed Development's probable route in Year 20 at sensitive non-residential receptors which are potentially impacted by aircraft noise.

12.9.58 Considering the magnitude of the impacts and the sensitivity of the receptors, significant adverse effects have been identified at the following non-residential receptors:

- Manston School House Nursery
- Chatham & Clarendon Grammar School
- The Elms Nursery School
- Priory County Infant School
- Masque Theatre School
- Fledglings Nursery School
- Ellington Cp School
- Christchurch Church
- Spitfire & Hurricane Memorial Building
- Pie Factory Music

12.9.59 The significant effect will be characterised by potential disruption, disturbance or interference with tasks by the users of the buildings.

12.9.60 The magnitude of the effect will depend on the existing ambient noise level at these receptors. For example at receptors which are already exposed to transport noise levels in excess of the impact

Both night time and daytime exposure to aviation noise impacts negatively on children's health, wellbeing and ability to learn. Stansfield et al particularly emphasise the need for '*school to be the main focus of attention for protection of children against the effects of aircraft noise on school performance'*.[21] RSP's woeful noise mitigation plan does not offer any reassurance here. Ramsgate schools, as with all schools, are suffering the impact of stringent cuts and are ill-placed to be able to

[21] Night time aircraft noise exposure and children's cognitive performance, Stansfeld, S, Hygge, S, Clark C, Alfred, T, Noise Health, 2010

put in place sufficiently effective noise insulation. In some case, old school buildings in conservation areas would be unable to ensure the most effective noise insulation because of planning restrictions.

Of course, no amount of insultation protects children from noise when outside playing or involved in sporting or other outdoor educational activities. Schools near Heathrow have resorted to building outdoor ‘pods’ for children to play in to protect them from the noise overhead. This is not a solution that seriously enhances children’s performance and wellbeing. A simpler solution is not to build a noisy 24/7 cargo hub so close to so many schools in an area of already relative deprivation.

In addition to the impact on cognitive function and development, studies have posited the detrimental effect on the physical health of children exposed to aviation noise nuisance in the short and long-term.

> *“An imbalance between leptin and ghrelin can lead to an increased sense of hunger with weight gain as a consequence. The risk of diabetes due to sleep disturbance and poor cognitive performance have been identified as accompanying long-term effects of disturbed circadian rhythms.”*[22]

Levels of obesity in some of the most deprived wards in Ramsgate, e.g. Newington, are already disproportionately high. These children and their families do not need an aggravating factor of this magnitude.

RSP says in its Environmental Statement at 15.8.10

> *“Depending on the existing ambient noise environment and existing building fabric, disruption to learning with measurable effects on reading age for children is possible at affected schools,*

[22] The Effects of Noise Disturbed Sleep in Children on Cognitive Development and Long-Term Health, published in the Journal of Child and Adolescent Behaviour in 2015 – page 6

prior to further mitigation. ***This could adversely affect quality of life and prospects for children concerned****."* [Emphasis added]

RSP acknowledges the serious adverse effect on quality of life and prospects. Yet their approach has been to ignore these children. Their application has not made any serious attempt to contextualise noise impacts in relation to these specific children, this specific population, these specific communities.

The Health and Social Care Act 2012 places a statutory duty on health services to reduce inequalities in health. There are severe inequalities with regard to the health of children in the UK and within Kent, and children in Thanet suffer some of the poorest health and health outcomes in the country.[23]

"Thanet is within the worst quintile in the UK for inpatient costs for under 5-year olds for a number of conditions including neurological, cancer and gastro-intestinal specialties but Thanet performs particularly poorly for musculoskeletal specialties with the second highest costs nationally per 1,000 population."[24]

Thanet also has a higher percentage than average of looked-after children. It is unacceptable that children living in an area which places them at serious health disadvantage - children living in an area where their life chances are already compromised - should be subjected an additional 'significant adverse effect' by RSP's aviation proposal and to the seriously detrimental impact of aviation noise on them as clearly identified by academic and medical research.

[23] Kent Annual Public Health Report, 2015

[24] Thanet Clinical Commissioning Group, Annual Report 2015/16 – page 12

Adults, the elderly, those living with chronic illness, those with mental health issues

The elderly are also at specific and particular risk of adverse health impacts as are those with pre-existing health conditions. Thanet has higher proportion of elderly people than the national average. An ageing population puts an increased burden on health services including mental health services – all of which are increasingly hard-pressed and over-stretched. A disproportionately high elderly population means higher levels of complex health and care needs and the higher prevalence of physical health conditions in this older age group contributes to higher rates of depression.

Thanet also has a high proportion of people with mental health needs. There is a high prevalence in the area of a wide range of unhealthy behaviours, such as smoking, binge drinking, obesity and generally unhealthy eating, all of which contribute to the disproportionately unhealthy population and the significant health inequalities of the area. Thanet has the highest rates of substance misuse in Kent, with drug and drink abuse resulting in significant health issues and needs. The life expectancy of Thanet residents is the lowest in Kent with very significant variations within Thanet itself. Thanet has a high mortality rate from coronary heart disease and there are significantly poorer outcomes for people with Chronic Obstructive Pulmonary Disease (COPD) in the area. Thanet has the highest prevalence of people with mental health issues compared to similar areas nationally. There is the 4th highest rate in England of emergency admissions for people aged 75 plus (with a stay of under 24 hours). Thanet has one of the highest rates of undiagnosed dementia in England.[25]

Thanet has a disproportionately aged population, a trend that is set to increase. In conjunction with the relatively high prevalence in the area of dementia and other chronic conditions, many associated with older age, the high number of care homes, in addition to the frail elderly being cared for at home, has been given scant attention by RSP. A thorough review of the numbers of care homes under the flight path and within the general area should have been undertaken and specific consideration given to the vulnerabilities of the people who live within these homes. Cross-cutting factors need to be considered across all demographic groups but perhaps in particular with regard to the cared-for elderly. Depression, for example, in older people affects up to 25% of the population and up to 40% of those living in care homes.[26] Noise insulation plans, in general, would not address the specific needs of this particularly vulnerable section of the population. In addition, the proposal's impact on their inability to enjoy and benefit from being outside should have been considered.

Thanet is an area of significant deprivation. The health impacts of aviation noise are well and increasingly evidenced. A proposal which acknowledges, yet significantly underestimates, the impact of noise on a population already hugely disadvantaged cannot be supported. The detrimental effects on the whole population but, most significantly, on the most vulnerable and at risk, cannot be ignored.

In recent years, the evidence that aviation noise impacts negatively on cardiovascular health has mounted. Increased risk of hypertension, heart attack and stroke are significant. Babisch and van Kamp (2009) evaluated the exposure-response relationship of the association between aircraft noise and the risk of hypertension. Due to the absence of large-scale quantitative studies there has been no clear association found between aircraft noise, ischemic heart disease, and myocardial infarction. However:

> *"There is sufficient qualitative evidence, however, that aircraft noise increases the risk of hypertension in adults."*[27]

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[25] Thanet Clinical Commissioning Group, Annual Report, 2015/16

[26] Age Concern. Improving services and support for older people with mental health problems. London: Age Concern; 2007 (cited in Mental Health Needs Assessment for Adults in Kent, Thanet CCG, 201)

[27] Environmental Research and Consultancy Department (ERCD), Civil Aviation Authority) Report 1208, Aircraft Noise, Sleep Disturbance and Health Effects: A Review, 2013 – page 37

The health effects of environmental noise created by aviation operations are diverse, serious and because of widespread exposure, very prevalent. For populations around airports, aircraft noise exposure can be chronic. The WHO guidelines for exposure to environmental noise are clear and the proposals from RSP would represent a breach of these guidelines.[28]

A study investigating the association of aircraft noise with risk of stroke, coronary heart disease and cardiovascular disease in the general population in 12 London boroughs and nine districts west of London found distinct and statistically significant trends.

> *'Hospital admissions showed statistically significant linear trends (P<0.001 to P<0.05) of increasing risk with higher levels of both daytime (average A weighted equivalent noise 7 am to 11 pm, $L_{Aeq,16h}$) and night time (11 pm to 7 am, L_{night}) aircraft noise. When areas experiencing the highest levels of daytime aircraft noise were compared with those experiencing the lowest levels (>63 dB v ≤51 dB), the relative risk of hospital admissions for stroke was 1.24 (95% confidence interval 1.08 to 1.43), for coronary heart disease was 1.21 (1.12 to 1.31), and for cardiovascular disease was 1.14 (1.08 to 1.20) adjusted for age, sex, ethnicity, deprivation, and a smoking proxy (lung cancer mortality) using a Poisson regression model including a random effect term to account for residual heterogeneity. Corresponding relative risks for mortality were of similar magnitude, although with wider confidence limits. Admissions for coronary heart disease and cardiovascular disease were particularly affected by adjustment for South Asian ethnicity, which needs to be considered in interpretation. All results were robust to adjustment for particulate matter (PM_{10}) air pollution, and road traffic noise, possible for London boroughs (population about 2.6 million). We could not distinguish between the effects of daytime or night time noise as these measures were highly correlated.'*[29]

Much of the research to date does not distinguish between daytime and night-time aircraft noise or have not been able to distinguish the separate causal links of daytime and night-time noise for a population that is exposed to both, or have not been carried out in people's own homes, or have insufficiently considered confounding factors. It is clear, however, that aircraft noise – day and night - has a detrimental impact on human health and wellbeing.

The Civil Aviation Authority's ERCD Report 1278, Aircraft Noise and Health Effects examined research evidence published since 2009 relating to transportation noise, in particular aircraft noise and the resulting impacts on various health endpoints. The findings within this paper should be carefully considered:

> *"It was reported that the results obtained when using the same categories for daytime and night time aircraft noise indicated that the relative risks for mortality were higher for night time noise."*[30]

> *"There is a need to understand the burden of disease and disability-adjusted life years in relation to noise exposure and cognitive impairment. To this end, longitudinal studies are needed for understanding the causal pathways between noise exposure and cognition. The long-term consequences of aircraft noise exposure, during early school life, on later cognitive development and educational outcomes have not yet been studied and remain important for policy making decisions. It is recommended that greater understanding is needed of the mechanisms of working memory and episodic long-term memory in children in relation to noise effects."*[31]

The research into causal links between aircraft noise, day, night-time and 24 hour, continues to mature and it is essential to consider the weight of evidence and interpretation over time and of most

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[28] Aircraft Noise Effects on Health, Queen Mary, University of London, 2015, for the Airports Commission – pages 26 to 27

[29] Aircraft Noise and Cardiovascular Disease Near Heathrow Airport in London, Hansell, A et al, BMJ, 2013

[30] ERCD Report, 1278, Aircraft noise and health effects: recent findings, 2016 – page 17

[31] Ibid – page 64

recent years. What is clearly established is that there is significant adverse effect on human health, in particular for those people in the most vulnerable groups.

The RSP proposal insufficiently examines risk, research and the real evidence available of the levels of noise that resulted from previous operations at the past airport. The result of these omissions is that RSP considerably downplays the negative impact on the local population of the day and night ATMs that it plans.

There are still relatively few studies that specifically look at the impact of aircraft noise on mental health. Some studies have provided support for the idea that 'psychological stress is induced by aircraft noise exposure, resulting in hypothalmus-pituitary-adrenal axis dysregulation and a flattened cortisol rhythm and, notably, a lower ability to decrease cortisol levels at night.'[32] The field is still immature and much work needs to be done, however, most studies confirm that there is a significant relationship between noise sensitivity or annoyance due to aircraft noise and psychological ill-health. 'This supports the hypothesis that psychological aspects, such as noise annoyance and noise sensitivity play important roles in the association between environmental noise and adverse effects on health.'[33] Given that Thanet has the highest prevalence of people with mental health issues compared to similar areas nationally. At Dashwood Surgery, under the flight path, the data show that there is a high recorded prevalence of depression and poor mental health, with values in the upper quartile for GP practices in Kent.[34]

It is unacceptable that RSP has failed to consider people with mental health issues as a significantly vulnerable group within the area and, accordingly, looked at their proposal with this group in mind. The fact that they have not done so is consistent with their blasé approach that the noise will be relatively minor and only small numbers of the population will be adversely impacted. This cavalier attitude towards a proper segmentation and consideration of particularly vulnerable sections of the population is evident throughout their application.

Noise at Night

Even though this is a developing field, and even though there is a need for further research fully to separate out the adverse impact of night noise and day noise, there have been many studies looking in particular at the impact of aircraft noise at night time on adults. Due to the increasing body of evidence showing that there is a negative impact on populations exposed to aviation noise nuisance at night, an increasing number of international and national policy guidelines and directives are seeking to prevent or decrease the numbers of night flights at airports where a large population would be adversely affected.

The HYENA study examined the impact of aviation noise on blood pressure in adults living near seven major European airports including London Heathrow.

> *"The HYENA study found that a 10dB increase in aircraft noise at night was associated with a 14% increase in odds for high blood pressure."*

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[32] Lefèvre, M.; Carlier, M.-C.; Champelovier, P.; Lambert, J.; Laumon, B.; Evrard, A.-S. Effects of aircraft noise exposure on saliva cortisol near airports in France. Occup. Environ. Med. 2017, 612–618. (cited in Aircraft Noise and Psychological Ill-health: The Results of a Cross-Sectional Study in France, International Journal of Environmental Research and Public Health, 2018)

[33] Aircraft Noise and Psychological Ill-health: The Results of a Cross-Sectional Study in France, International Journal of Environmental Research and Public Health, 2018, page 1)

[34] Thanet CCG, Analysis of Deprived Areas, 2016, p 14

“It also found that a 10dB increase in night time aircraft noise was associated with a 34% increase in the use of medication for high blood pressure in the UK.”[35]

A research study carried out in Greece with people living near to Athens International Airport, as published online in Occupational and Environmental Medicine, found significant adverse effects.

‘Between 2004-6 and 2013, 71 people were newly diagnosed with high blood pressure and 44 were diagnosed with heart flutter (cardiac arrhythmia). A further 18 had a heart attack.

Exposure to aircraft noise, particularly at night, was associated with all cases of high blood pressure, and with new cases.

When all cases of high blood pressure were included, every additional 10 dB of night-time aircraft noise was associated with a 69% heightened risk of the condition. When only new cases were included, every additional 10 dB was associated with a more than doubling in risk.’[36]

Elmenhorst et al (2010) looked at night time aircraft noise and the impact on cognitive performance the following day:

“The authors propose that the results hint at changes in physiological processes due to nocturnal aircraft noise exposure. Only healthy adults were included, however, the researchers infer that the effects of nocturnal aircraft noise may result in stronger impairment in vulnerable groups such as children or people who are ill.”[37]

The significance of sleep to human health is increasingly being investigated as it is during the night that the body undergoes specific restorative functions. Anything that prevents this necessary physiological ‘repair’ work and energy saving functions can be detrimental to health:

“Often, there is a discussion that sleep represents a trophotopic phase (energy storing), contrasting with an ergotropic (energy consuming) phase when we are awake (Maschke and Hecht 2004). Therefore, frequent, or long-awakening reactions endanger recovery and therefore health. Such frequent occurrences of arousal triggered by nocturnal noise can lead to a deformation of the circadian rhythm. Also, the deep SWS phases in the first part of the night are associated with a nadir of cortisol, and a maximum of growth hormone, both necessary for the physical wellbeing of the sleeper.”[38]

Research showing an association with aircraft and road noise and cardiovascular disease measures continues to mature. There is emerging evidence to suggest that cardiovascular effects are more strongly linked with night time noise exposure as opposed to day or total (24hr) noise exposure.

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[35] Aircraft Noise Effects on Health, Queen Mary, University of London, 2015, for the Airports Commission – page 3

[36] BMJ. "Long term exposure to aircraft noise linked to high blood pressure: Night-time noise may be particularly influential, findings suggest." ScienceDaily. ScienceDaily, 13 June 2017. <www.sciencedaily.com/releases/2017/06/170613185148.htm>.

[37] ERCD Report, 1278, Aircraft noise and health effects: recent findings,2016 – page 50-51

[38] ERCD Report 1208, Aircraft Noise, Sleep Disturbance and Health Effects: A Review,2013 – page 39

“With regard to night noise and sleep disturbance, there is growing recognition that average indicators such as Lnight are insufficient to fully predict sleep disturbance and sleep quality and that use of number of noise events (LAmax) will serve to help understanding of noise-induced sleep disturbance.” [39]

The NORAH Sleep Study examined how nocturnal flights affect people’s sleeping habits. The study paid special attention to the effects of two new measures, which changed the noise background in the Rhine-Main Region in October 2011. Since then there has been a curfew at Frankfurt Airport on scheduled take-offs and landings between 11 pm and 5 am. At the same time, the new North-West runway began operations. A comparison of the sleep measurements from 2011 and 2012 shows how the changes affected residents with otherwise healthy sleep patterns.

‘The residents around Cologne/Bonn Airport got less rest when they were asleep than the Frankfurt study participants after the introduction of the curfew on scheduled flights between 11 pm and 5 am. According to the sleep measurements carried out in the Rhineland, the participants spent less time per night in the deep sleep phase which is so important for rest.’[40] *12*

‘With the new “vegetative-motor” method used by NORAH, the focus of the scientists was brought back to the fact that nocturnal overflights can, in many cases, increase the heartbeat of sleepers. It even happens that people appear to continue sleeping peacefully, but still show a physical reaction.’[41]

The NORAH study on health risks produced a number of findings:

‘For aircraft noise, the NORAH team found a statistically significantly increased stroke risk in persons with a long-term energy equivalent sound level below 40 dB if the maximum sound level at night exceeded 50 dB.’[42]

In terms of cardiac insufficiency, where the heart is no longer able to sufficiently supply the body with blood, the NORAH study showed a statistically significant increase of 1.6% per 10dB.[43]

It is evident that there are particular and specific negative health impacts associated with aircraft noise at night time and it is important that the inspectors read the body of evidence available to date that confirms this.

Consulting with regard to health and wellbeing

RSP has undertaken only the bare minimum of consultation with regard to the population’s health and wellbeing. There has been consultation with the Kent Director of Public Health and the Clinical Chair of Thanet Clinical Commissioning Group but two individuals is extremely limited and falls significantly short of the sort of consultation, research and referencing that would be considered best practice.

In preparing their noise impact assessment, a full range of stakeholders should have been consulted. With regard to the specific population potentially impacted by this proposal, a wide range of clinical opinion, particularly with regard to existing chronic health conditions prevalent in the local population and those particularly likely to be aggravated by the adverse impact of aircraft noise, should have been consulted.   A full range of mental health experts; teachers, headteachers and educationalists;

[39] ERCD Report, 1278, Aircraft noise and health effects: recent findings,2016 – page 65

[40] NORAH< Knowledge No 10, Aviation noise and nocturnal sleep, p 12
[41] NORAH< Knowledge No 10, Aviation noise and nocturnal sleep, p 16
[42] NORAH, Knowledge No 12, Study on Health Risks, p 8
[43] NORAH, Knowledge No 12, Study on Health Risks, p 9

allied healthcare professionals; social care specialists and practitioners and care home owners and managers should have been interviewed.

Underpinning their application, with regard to noise impact, specifically in relation to health and wellbeing, should have been a solid body of evidence drawn from the widest range of up-to-date research on this topic in addition to a close and contextualised analysis of the specific health, wellbeing and health inequalities position locally. Only by doing this could RSP establish a credible health and wellbeing baseline.

It is vital that RSP consider fully the impact of its proposals on populations already deprived, already suffering some of the worst health inequalities in the country, already marginalised and under-supported by health and care provision. They have failed to undertake a credible impact assessment.

RSP's summary of community health needs and objectives (15.4.3 onwards) appears to suggest that correcting lifestyle and behaviour choices in the population, as part of local authority and health services planning and objectives, will result in improved health in the local population and therefore RSP needs to pay less attention to the adverse health impact of its proposal. This optimistic approach fails to consider the wider adverse impacts of RSP's proposal on environment, lifestyles, local regeneration and local communities etc. that may in themselves mitigate against any hoped-for improvements in lifestyle choices planned for against the status quo. RSP says that the Thanet CCG Chair noted 'the need for jobs in Thanet with the importance of socio-economic benefits to health'. However, this is not the same as the Thanet CCG Chair saying that RSP's proposal will have a net positive impact on health locally. One could equally say that the jobs proposed by the landowner of the airfield site would bring about the same desired health benefits.

In Table 15.4, RSP acknowledges that impact characteristics during the operational phase of its proposal with regard to airport and aircraft noise are "direct, adverse, local and long-term". Similarly, with regard to airport/aircraft air pollutant emissions, the impact characteristics are "direct, adverse, local and long-term". At 15.8.4, the applicant says that:

> "*These results indicate that the Proposed Development would lead to a potential 2% to 3.6% increase in cases of hypertension within the population exposed to Year 2 noise levels, rising to approximately 3.2% to 5.6% additional cases at Year 20 levels"*
>
> *"The evidence suggests that the relative change in noise also has the potential to contribute towards approximately one annual incident case of disease or mortality from ischaemic heart disease or stroke at Year 2 levels, rising to around two to four cases at Year 20 levels. This corresponds to a 2.8% to 4.3% change in background incidence*."

The applicant has not demonstrated how any benefits that could conceivably flow from its proposals would outweigh the cost in additional disease and death for the local population.

As has already been discussed in the foregoing sections on noise and night flights, the basis on which RSP's health impact predictions are made is fundamentally flawed and the adverse impacts described can be expected to impact a far higher proportion of the population. RSP must be interrogated on its noise contouring and noise methodology. RSP should be required to consider a more realistic assessment of the adverse impact of its proposal on health taking onto account the historic noise data relating to the airport and the WHO's evidence about the impact of noise on health.

Independent Commission on Civil Aviation Noise

As a result of one of the Airports Commission's recommendations, the Independent Commission on Civil Aviation Noise (ICAAN) is being set up. This publicly funded body is established with the 'statutory right to be consulted on flight paths and other operating procedures.' The authority is to be given 'statutory consultee status and a formal role in monitoring and quality assuring all processes and functions which have an impact on aircraft noise and in advising central and local Government and the CAA on such issues.'[44] (page 14)

The DfT's success criteria for ICCAN include that 'the SofS is effectively supported in his role with regards to noise within strategically significant decisions'. With regard to this specific application, it appears that the ICCAN may be insufficiently mature to be able to present evidence into the process and for it to advise the SofS. Notwithstanding, it would not be within the spirit of the Airports Commission recommendations nor the subsequent setting up of ICCAN for this examination process to ignore this body. Given its statutory role, given that this is the first DCO with regard to an airport, given government policy that has rejected the creation of new airports, given that government policy in no way supports the development of a 'nationally significant' cargo airport at Manston, given government and international principles and guidelines with regard to noise, it seems inconceivable that the this process and the SoS decision-making should be undertaken in absence of any input form this body.

Conclusion

RSP's proposal represents a serious threat to the people of Ramsgate.

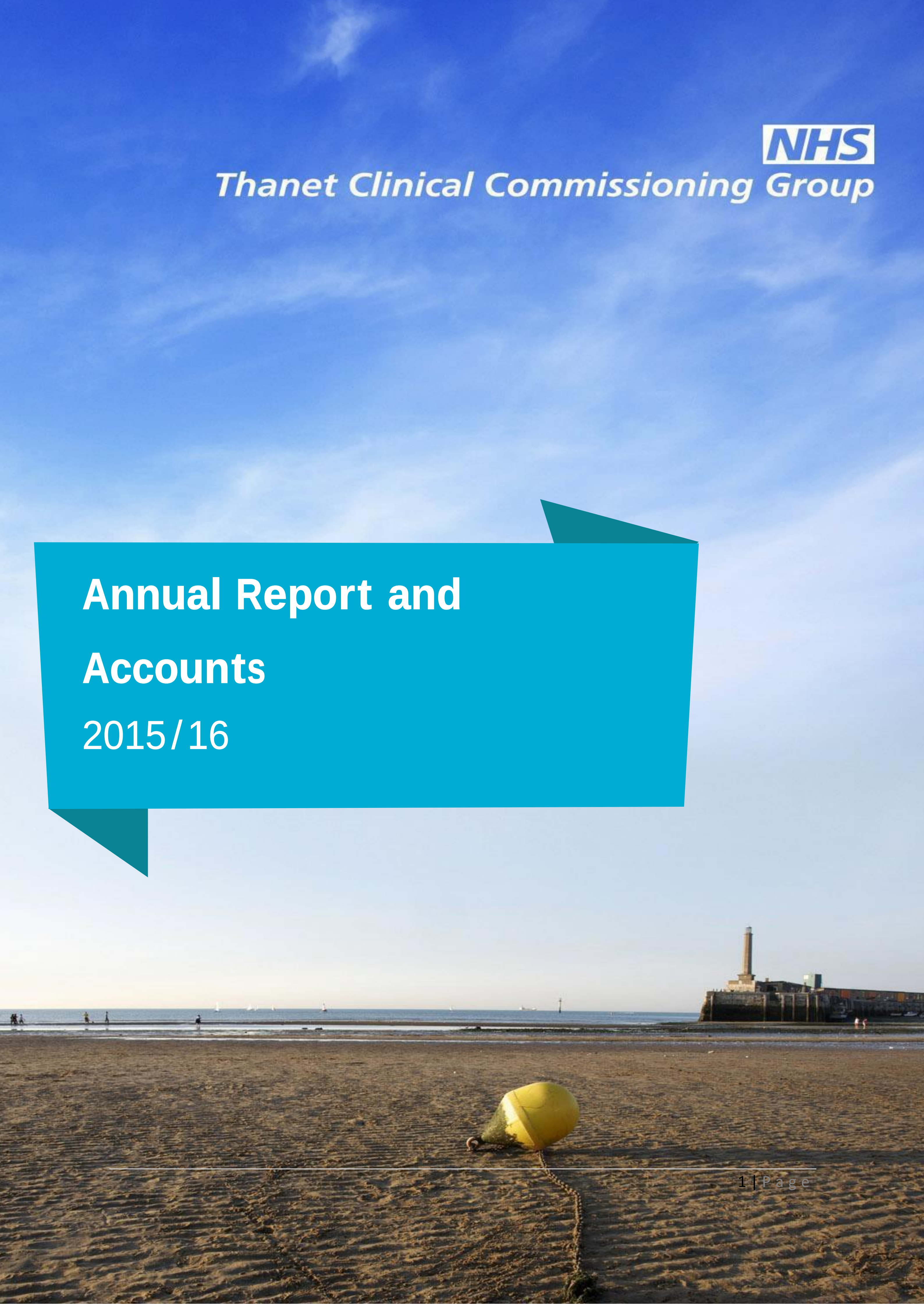
It's noise modelling and noise mitigation plans are fundamentally flawed and completely underestimate noise levels and noise impact on many more thousands of people than they allow for.

With such serious flaws in their methodology and presentation, it is impossible for their noise impact assessment to be credible. If proper consideration of the adverse impact of aviation noise on local populations and their health is to be undertaken, their proposal must be fully interrogated and rewritten.

Essential to this examination stage is a full presentation and questioning of comparative and historic noise data which sheds an entirely different light on the applicant's proposal. Deliberately underplaying the extent to which noise will impact on people has consistently been a tactic that seeks to present only alleged benefits. RSP's proposal is simply not in any alignment with international and national guidance and directives, let alone principles, with regard to aviation noise and population health and wellbeing.

The National Planning Policy Framework (NPPF) says that 'the planning system can play an important role in facilitating social interaction and creating healthy, inclusive communities (Paragraph 68). It is to be hoped that the planning system recognises this role and refuses this application.

[44] House of Commons Briefing Paper, Number SN261, 2017



NHS
Thanet Clinical Commissioning Group

Annual Report and Accounts

2015/16

Contents

Annual Report for Thanet CCG 2015/16

This is the third Annual Report from NHS Thanet Clinical Commissioning Group (CCG). The Thanet CCG Annual Report and Accounts for 2015/16 covers the period from 1 April 2015 to 31 March 2016.

This Annual Report is published in accordance with the National Health Service Act 2006 (as amended) which requires CCGs to prepare their Annual Report and Accounts in accordance with Directions issued by NHS England. It is in three parts:

- A Performance Report
- An Accountability Report
    - The Members' Report
    - Statement Made by the Accountable Officer
    - Annual Governance Statement
    - Remuneration and Staff Report
- The Annual Accounts

Foreword from the Clinical Chair

Since its inception in 2013, Thanet CCG has always sought to work for the people who live in the area and use its health services.

That central tenet still holds true although we face significant challenges. However, there are real opportunities to transform healthcare in a way that improves health and well-being. Underpinning our philosophy is a belief in the importance of empowering the people of Thanet to make good decisions about their own health: supporting self-care is high on our agenda.

The pressures that Thanet faces are not unique to the area. We have an ageing population, challenging health inequalities, too many urgent care admissions and more people experiencing long-term health conditions. However Thanet also has pockets of deprivation relating to joblessness, deprivation and the placement of vulnerable people where these factors come together in a way more usually found in inner-city areas of the UK.

This means that we have to review our commissioning decisions carefully and allocate resources accordingly. We also can not make the changes we want to make on our own. That is why we are working with our local government partners, other health and social care providers in the area and the voluntary sector to deliver our strategy of integrated care. We want to see organisational barriers which stop people working together effectively removed so that we can deliver better care for patients.

We believe that “local” is usually the best level at which services are delivered. We have focused on developing primary care in four localities in Thanet – Margate, Ramsgate, Broadstairs and Quex (rural Thanet) – so that GPs are at the centre of 7 day coordinated care provision in the community. This work is making progress and we will continue to focus on improving primary care during 2016/17.

We will also continue to emphasise the importance of mental healthcare provision for both children and adults, because in Thanet we have a higher-than-average number of patients with these problems. The links between physical and mental health are strong, and Thanet is making good progress in addressing these needs, particularly with increased referrals for talking therapies. We are responding to the Government's key strategy document, *Five Year Forward View: Mental Health.*

Dr Tony Martin
Clinical Chair on behalf of 17 GP practices of Thanet
May 2016

PERFORMANCE REPORT

Overview

This section of the Annual Report sets out information about the CCG's purpose, what it has done to deliver its purpose and an assessment of how well it has done.

The Responsibilities of the CCG

The Thanet CCG was established in April 2013 under the Health and Social Care Act 2012 as a body corporate. The CCG has responsibilities for commissioning services to meet the healthcare needs for approximately 143,000 people registered with GP practices in Thanet. The services we commission include:

- Community health services (except where part of the public health service)
- Maternity services
- Urgent and emergency care including Accident and Emergency, ambulance and out- of-hours services
- Elective hospital care
- Older people's healthcare services
- Healthcare services for children including those with complex healthcare needs
- Rehabilitation services
- Wheelchair services
- Healthcare services for people with mental health conditions
- Healthcare services for people with learning disabilities
- NHS continuing healthcare.

Although the CCG does not commission pharmaceutical services, we are responsible for the costs of prescriptions written by local GPs. We do not commission dental services or sight tests. Specialist health services, such as secure psychiatric services, continue to be commissioned by NHS England.

At the moment the CCG does not commission GP services, which are commissioned by NHS England. However, the CCG does have a major part to play in improving the quality of primary care and our Membership Development Team, led by several Clinical Leads, work with all the GP practices to help them improve. During 2015/16 NHS England asked all CCGs to re-consider whether they were willing to take on commissioning primary care services, either jointly with NHS England or on their own. While the members of the CCG agree that local commissioning of services works best, we considered the options carefully but decided to continue with the current arrangements for a further 12 months. The Membership will consider this issue again in November 2016.

Meeting the Health Care Needs of Local People

There are significant levels of deprivation in Thanet. It is ranked in the 10% most deprived districts in England and more than a quarter of the children in Thanet are classed as living in poverty.

- ### Population

  Compared to the Kent average, Thanet has a lower percentage of people of working age and a higher proportion of elderly people

  Thanet's population is ageing: currently 22.6% of the Thanet population are aged over 65 and this is predicted to continue to rise significantly over the next 20 years.

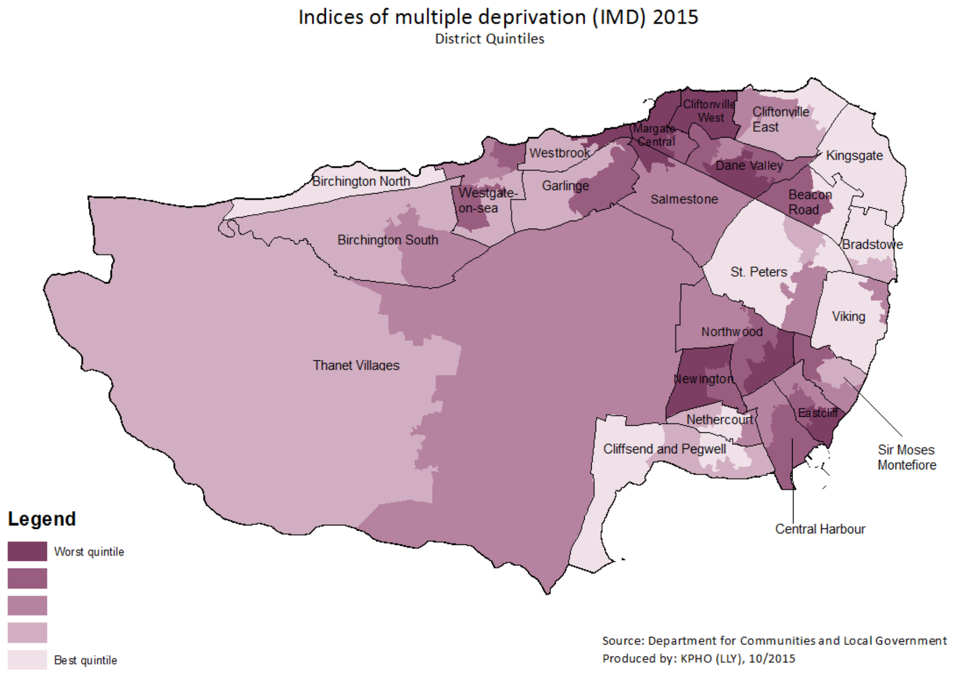
- ### Geography

  Thanet is made up of three coastal towns, Ramsgate, Margate and Broadstairs with a rural hinterland of a number of small villages. The area is dependent on tourism, meaning the coastal towns in particular face the socio-economic disadvantages common to many such areas.

  Levels of unemployment have risen in recent years and remain the highest in Kent, with 2.6% of working people claiming Job Seekers Allowance (twice the Kent average).

  Thanet has significant areas of high deprivation in both Margate and Ramsgate, and comparatively few areas of affluence. Of the 84 lower super output areas (LSOAs) in Thanet, 18 are in the 10% most deprived in the country. One area of Cliftonville in

Margate has been classed as the 4th most deprived of the 32,844 LSOAs in the country.[1]



- ## Vulnerable People

Thanet's seaside location has made it a popular retirement destination leading to a high proportion of older people within the population. The health needs of the older population tend to be more complex and this puts greater pressure on health services locally.

Thanet has a high proportion of people with mental health needs, and also has a very high proportion of looked after children (LAC) and care leavers. The number of LAC is over twice the Kent average and 45% of these originate from outside of Kent (figure 5).

1 https://www.gov.uk/government/organisations/department-for-communities-and-local-government

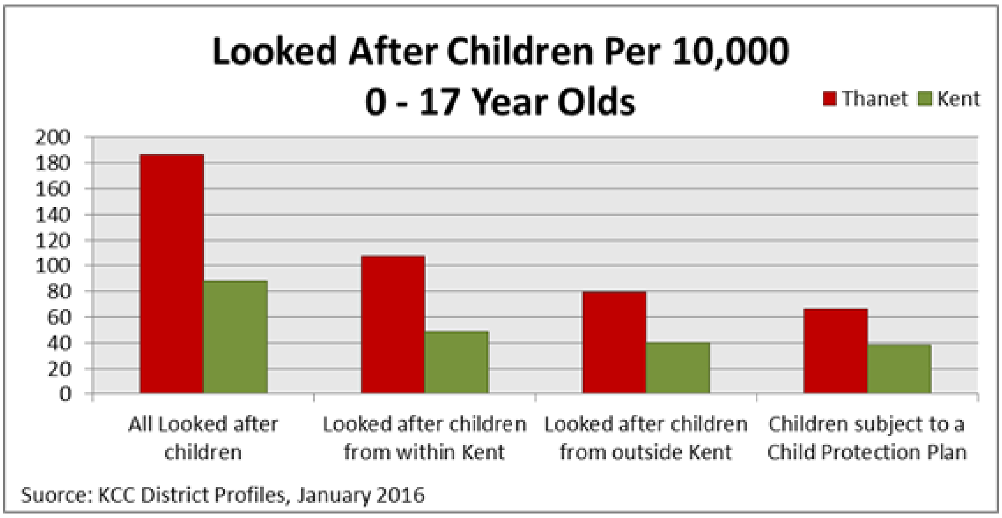


Figure 5

The rate of children in 'poverty' (proportion of children in families living in receipt of out of work benefits or tax credits where their reported income is less than 60% median income) is higher in Thanet at 25.1%, vs 15.6% in KCC area.

- ## Lifestyle

Within Thanet there is a high prevalence of unhealthy behaviours, such as smoking, obesity, binge drinking and unhealthy eating. It is estimated that less than 30% of people in Thanet eat the recommended amount of fruit and vegetables. Thanet has the highest levels of smoking within Kent. One in five people within Thanet are classified as obese. There are also wards where the estimated prevalence of binge drinking is estimated to be more than 20% (for example in Cliftonville West). Therefore it is vital that health services in Thanet support people to develop a healthy lifestyle. Health promotion needs to be relevant and achievable.

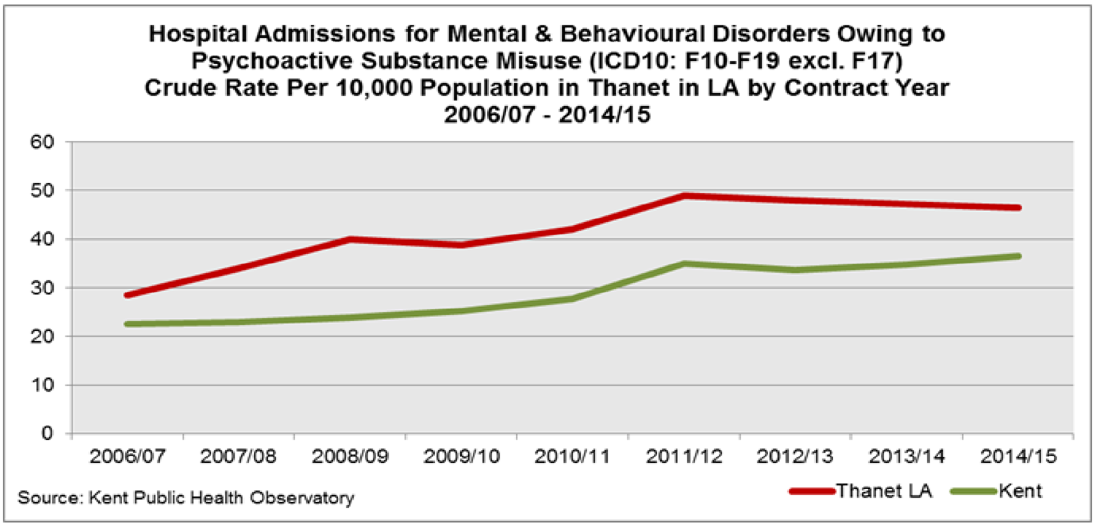
- ## Crime and Substance Misuse

Thanet has a higher crime rate per 1,000 population than any other district in Kent (83.54 for year ending June 2015 vs 61.13 Kent average[2]). The rate of violent crimes (including sexual offences) per 1,000 population is 26.49 vs a Kent average of 17.97.

[2] https://www.thanet.gov.uk/publications/housing/selective-licensing-scheme-2012-2016/the-profile/

Thanet also has the highest rates of substance misuse in Kent with significant amounts of alcohol-related harm and the highest rate of drug offences across the Kent policing area. This places further burdens on the health economy, for example hospital admissions for mental and behavioural disorders owing to psychoactive substance misuse per 10,000 population are significantly higher than the Kent average.

Figure 6.



Health Inequalities in Thanet

Health inequalities in Thanet are a serious concern. The CCG regularly reviews information reported through a variety of sources such as the Atlas of Variation and Commissioning for Value packs as well as other sources such as the Kent Joint Strategic Needs Assessment (JSNA). The following highlights some of the key issues locally.

- ### Life Expectancy

The life expectancy of Thanet residents is the lowest in Kent at 80.19 years. Within Thanet there are significant variances with a gap of 17 years between Margate Central ward (73.6yrs) and Kingsgate ward (90.3yrs).

- ## Mortality and Long Term Conditions

During 2014, 30% of all deaths in Thanet had an underlying cause of cancer. According to 2014/15 Quality Outcomes Framework (QOF), Thanet had a 2.66% prevalence of cancer, compared to 2.47% during the previous year. This was the third highest rate across Kent and Medway. One year survival rates after a cancer diagnosis were last reported at 64.1% (2012-13); this is in the worst quintile nationally. The death rate from cancer in people aged under 75 years is 150 per 100,000 - in the worst quartile nationally.

Thanet has a high mortality rate from coronary heart disease (CHD) but a low diagnosis rate. We spend £1.9 million more on care for patients with circulation problems than some of our demographically similar peers and yet outcomes for patients and the quality of care are not as good. The picture is similar for respiratory problems with more money spent than similar CCGs but with poorer outcomes for those with Chronic Obstructive Pulmonary Disease (COPD). Work has started at our Bethesda practice to improve identification of people with CHD

Obesity in Thanet was 9.9% in 2013/14 in line with the rest of Kent (9.8%). Whilst Thanet is not a particular outlier for obesity or diabetes, the impact of growing obesity and increases in the number of people with diabetes is having the same impact within Thanet that is being seen nationally. When we compare ourselves to demographically similar CCGs, we spend more on care for patients with diabetes but do not achieve the same outcomes for patients.

- ## Mental Health

Thanet has the highest prevalence of people identified with mental health issues when compared to similar CCGs nationally. According to the 2014/15 QOF data, prevalence was at 1.04%, higher than 1.01% for the previous year.

There is a rising demand for Child and Adolescent Mental Health Services and specifically ASC/ADHD diagnosis and treatment services.

Compared to demographically similar CCGs we have not achieved the same level of quality of care for people with mental health conditions.

- ### Children and Maternity

Thanet is within the worst quintile for inpatient costs for under 5 year olds for a number of conditions, including neurological, cancer and gastro-intestinal specialties, but Thanet performs particularly poorly for musculoskeletal specialties, with the second highest costs nationally per 1,000 population.

Thanet has the highest teenage conception rate in Kent at 39 conceptions per 1,000 females aged 15-17. In Cliftonville West the rate is close to one in ten. In addition 20.2% of women in Thanet are recorded as smokers at the time of delivery. This is the highest rate not only in Kent, but across all NHS England South (South East) CCGs.

- ### Frailty

Thanet has a high rate of emergency admissions for people aged 75+ with a length of stay of less than 24 hours. The rate is the highest across similar CCGs to Thanet, and is the fourth highest rate of all CCGs in England.

Thanet has one of the highest rates of undiagnosed dementia in England, currently it is estimated that around 40% of cases are undiagnosed. Thanet also has a high rate of emergency admissions to hospital of people with dementia.

Thanet is also in the lowest quintile for reported health gain from hip replacements and has a high rate of emergency readmissions within 28 days following hip replacements.

What Local People Have Said

Our strategy to enable us to meet our responsibilities takes account of the health needs of the population and has been developed in consultation with local people. We are committed to ensuring patient and the public views are at the heart of shaping our healthcare services. Over the past year we have been listening, engaging and involving patients and the public. These are some of their concerns

- Patients are concerned about the difficulty in obtaining GP appointments
- Patients believe there is a need for a seven day service
- Patients are concerned about a shortage of consultants (e.g. Stroke and A&E consultants)
- Patients are concerned about excessive waiting times
- Patients believe that rehabilitation and after-care needs to be improved as after-care is poor following discharge.
- Patients are concerned about the distance between hospitals
- Patients are concerned about the way funds are allocated for Personal Health Budgets and the costs associated with running the scheme.
- Patients would like more initiatives like “Thanet Big Health Checks” taken into places such as schools, surgeries, supermarkets and pharmacies.

The CCG’s Strategy: Transformation and Integration

We have used the information we have about local health challenges, taking account of what local people say, what our members are saying, what the NHS has mandated for us nationally, and what our partners on the Kent Health and Wellbeing Board and the Thanet Health and Wellbeing Board have agreed to develop our strategy.

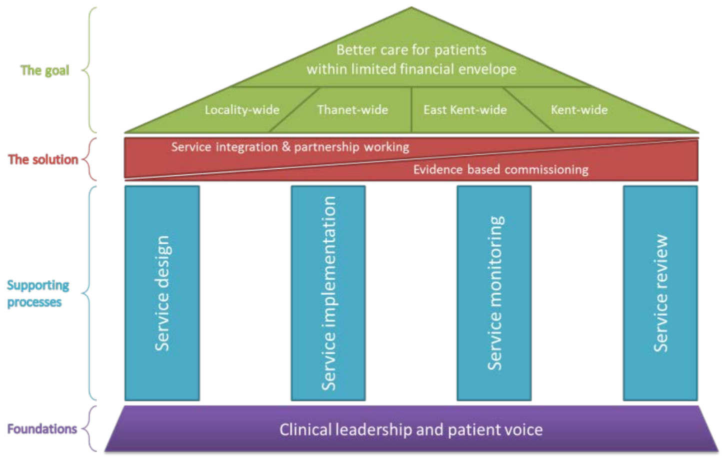
As a CCG, we want to build a local health system that works together, delivers clinically safe and effective services for the public in a timely manner, offers value for money and raises the quality of patient care. A key part of our strategy is to develop and deliver a new model of integrated care that is “wrapped around” individual patients, rather than being provided in a piecemeal way to the preferences of the different organisations providing care. Within Thanet this approach will be delivered via a Multispecialty Community Provider (MCP) operating as an Integrated Accountable Care Organisation (IACO).

Improving care and developing more integrated patient pathways will add value to patient experience, improve outcomes and save money which can be reinvested elsewhere into the care system.

We identified five aims which would enable us to move towards achieving our strategic goals. These were that all patients should receive:

- High quality, equitable, accessible and integrated GP Services
- High quality, integrated out of hospital care covering physical and mental health
- Timely, clinically appropriate and high quality care in hospital
- High quality mental health and wellbeing care in the most appropriate setting
- High quality children's and maternity services

In achieving transformational change we will continue to draw on our patients' views and use robust needs assessment in identifying our priorities. The commissioning and redesign of services will be informed by effective clinical engagement, recognised best practice, and performance data analysis, in a context of an absolute requirement for improving the health and social care outcomes and system sustainability.



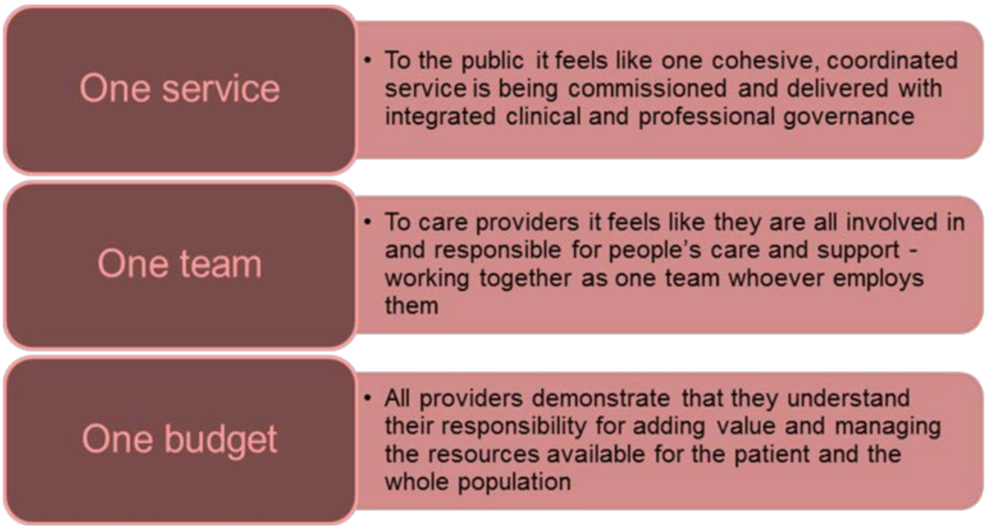
Working in Partnership to Deliver Integration

Thanet CCG and other local NHS and social care partners recognise that the current pattern of health and social care locally cannot continue in its current form. As populations become older and are living longer with more complex conditions, there is a growing demand on health and care services. With the current financial position and the public wanting integrated services to support independence in their own home, it has become essential that care is delivered differently to meet demand and improve quality and outcomes.

Thanet CCG believes that integration of health and social care is the way forward; delivering better care, improving quality and outcomes for citizens as well as efficiencies across the system. Integrated Care is a fundamentally different way to meet health and care needs for a defined population and tailored care to meet individual needs. It means changing the design of services, the people that deliver them and how services are paid for.

Integrated care service models mean that the traditional segmentation of care by provider organisations is no longer appropriate. In the first instance, integrated care means that care services, the care team, and the overall budget for the health and care for a defined community have to be brought together.

The vision for integrated care within Thanet:



Thanet CCG has an outline model for integration which has been designed locally. The Thanet vision for integrated health and social care will be delivered via a MCP operating as an Integrated Accountable Care Organisation (IACO). Ultimately, the aim is to deliver a model for health and care services out of the acute hospital, wrapped around the patient and co-ordinated by their GP, designed and delivered around local patients. The service model will provide strong town based (Margate, Ramsgate, Broadstairs and Quex) integrated health and social care teams – built to enable GP practices to work together within a single infrastructure. This local service model will be supported through a 'hub' based at the local acute hospital. QEQM (the local acute Hospital which currently forms part of EKHUFT) will be redesigned as part of the Hospital Trust's clinical strategy aligned with the Thanet IACO to be a 'community orientated acute site'. QEQM is ideally physically positioned to be only a short distance from most patients. Serving a population of more than 140,000, the services that can be brought into and maintained for the Isle economically are considerable.

More about the IACO can be found in our Operational Plan for 2016/17 at http://www.thanetccg.nhs.uk/home/

We cannot achieve this vision on our own. Delivering this vision involves us working closely with local people and organisations, including Kent County Council, Thanet District Council, providers of health and social care and the voluntary and community sector to prioritise and co design the services that each community needs.

We have worked with our partners as a whole system. Our health partners include the local providers – East Kent Hospitals University Foundation Trust (EKHUFT), Kent Community Health NHS Foundation Trust (KCHFT), NHS Kent and Medway Social Care Partnership Trust (KMPT), South-East Coast Ambulance (SECAMB) and other CCGs in Kent and Medway, particularly those in East Kent.

We also work with Kent County Council and Thanet District Council through the local Health and Wellbeing Board and the Kent Health and Wellbeing Board, to make sure that what we commission can be delivered at the most appropriate level through the NHS and social care working together. A key platform for improving the health economy of Thanet is through the Thanet Health and Wellbeing Board, which is helping us improve mental health, children and maternity services and care for Over 75s. The local Health and Wellbeing Board aims to become an equal partnership of local commissioners working in a single commissioning structure to oversee the local health and wellbeing system. Pooled budgets are an aspiration for the future. At the moment, each commissioning partner retains control of its own budget.

Integration Using The Better Care Fund

Thanet CCG realises the opportunity that joint commissioning and the Better Care Fund (BCF) can provide to meet the health and social care needs of the local population in an integrated and shared way. The BCF is best described as a single pooled budget for health and social care services to work more closely together in local areas. This offers a substantial opportunity to bring resources together to address immediate pressures on services and lay foundations for a much more integrated system of health and care delivered at scale and pace.

Within our plan we have set out a clear vision of how services will look by 2020. We have used the basis of the BCF to support 6 key programmes. These are:

1. Enhanced Primary Care – including self-care
2. Integrated Health and Social Care teams
3. Flexible use of care homes

4. Falls prevention
5. Support for carers
6. Improving end of life care

We will use these areas to help us deliver change within our local health economy, with the patient at the centre of delivery.

We are committed to not only providing seven-day health and social care services but also furthering this to a proactive model of 24/7 community based care. Adult Social Care has shifted working hours to be 8am to 8pm, seven days per week as standard. Further work is taking place within the Adult Social Care Transformation Programme to identify the steps required to achieve extended working hours in all areas of delivery.

East Kent Strategy Board

The four East Kent CCGs and partners have agreed to work together to develop the model of health and social care services for East Kent. The partners aim to achieve the following outcomes:

- A consensus about how to meet the current and future needs of local people, building a model of care which is based in the local community wherever possible and is co-ordinated by the GP around the patient
- Options to deliver the model of care will have clinical credibility and ensure patient safety
- A service model that is supported by the local population and their political representatives
- The model of care that provides equality of access to users
- A model of care which is proactive and sustainable for the future, including providing equality of access to high quality services for local people

Our progress during 2015/16

High quality, equitable, accessible and integrated GP Services

- Progressed integrated working at practice level through the development of four localities within Thanet: Margate, Quex, Ramsgate and Broadstairs.
- Established integrated community nursing teams in the Margate locality, with teams in Quex, Ramsgate and Broadstairs due to come on line over the coming months.

High quality, integrated out of hospital care - physical & mental health

- Increase in the proportion of people with dementia who are diagnosed from 49% to 61.1%
- Age UK service provided support for 375 vulnerable elderly people within the community. An improvement in wellbeing was noted for 96% of patients who were assessed before and after they received the service.
- Introduction of bespoke dementia service delivered by Crossroads Care which provided a range of support including personal care, help with medication and night sits to enable carers to have an uninterrupted night's sleep. During the first three months of the service, eighteen patients with dementia have had their hospital stay made shorter or prevented.
- Agreed improved medicines care arrangements for the Victoria Unit at Westbrook House, ensuring patient safety is maintained.
- Launched new and improved COPD pathway with the introduction of the Patient Passport.
- Developed East Kent carer patient information packs and introduced 'Just in Case' medication boxes as part of palliative care which aims to keep people in their place of choice at the end of their life.

Timely, clinically appropriate and high quality care in hospital

- 3200 GP referrals for trauma and orthopedics reviewed by the new Collaborative

Orthopedic Referral Point (CORP) ensuring appropriate care provided for these patients and reducing pressure on hospital resources.

- Reduction of 3.7% in the number of non-elective admissions for over 75s.
- Implementation of ‘Discharge to Assess’, to support smooth flow through A&E, avoid hospital admissions and reduce delayed transfers of care.
- 99.8% of diagnostic tests carried out within 6 weeks of referral.
- 81% of life threatening emergencies were responded to by ambulance services within 8 minutes (national target 75%).

High quality mental health & wellbeing care in the most appropriate setting

- 25% of the estimated number of people suffering from depression and anxiety in Thanet accessed psychological therapies (national target is 15%).
- Reduction of 48% in the average numbers of mental health inpatients placed out of area over the second half of the year, enabling patients to be closer to their families and support networks.

High quality children’s and maternity services

- Established the new East Kent Children’s commissioning team hosted by Thanet CCG. Strategy and work plan developed.
- Submitted transformation plan for children and young people’s mental health and successfully achieved funding.
- Implemented transformation schemes:
    - Support for children in schools demonstrating risky behavior particularly relating to self harm;
    - Collaborated with other CCGs on services for unaccompanied asylum seeking children;
    - Increased capacity for eating disorder intervention;
    - Commissioned 3rd sector organisation to support schools regarding emotional wellbeing and resilience;

  - Continued scheme to provide 24hr psychiatric liaison service for children after the ending of winter pressure funding.
- Agreed action for Looked After Children (LAC) placed within Thanet with other public sector partners.
- Agreed local offer for personal health budgets to be in place from April 2016.

There is still much more to do

- Only 86.3% of patients at East Kent Hospitals stay less than four hours in A&E (national target 95%).
- Compliance with the referral to treatment standard was not sustained.
- Unable to meet cancer waiting times standards consistently.
- Under-reporting of activity undertaken by Kent Community Health NHS Foundation Trust.
- A number of CQC inspections reported failings relating to care provided in hospital and out of hospital.
- Closure of two GP practices and some care homes resulting in reduced capacity in the local health economy.
- A significant increase in the number of delayed transfers of care from community and mental health hospitals, particularly relating to patients requiring social care support.

Financial Overview

The CCG has met its statutory duty to achieve financial balance in 2015/16 and has completed its third year of operation achieving its statutory financial targets. However, the CCG used all its contingency funds set aside in order to do this. The cost improvement programmes included within the Quality Innovation, Productivity and Prevention (QIPP) achieved an overall reduction in expenditure of £4.21m. The CCG managed to achieve a 1% surplus (£2.097m), as agreed with NHS England.

Thanet CCG has approved its budget for 2016/17 to enable it to deliver its strategic objectives. The CCG has an annual budget of £210 million to pay for healthcare for the

143,000 people registered with a GP practice within Thanet. That equates to around £1,472 (2015/16 £1,442) per person. More detail about the income and expenditure of the CCG will be found in the annual accounts. The external auditors have confirmed that the CCG remains a going concern.

We commission health services primarily from 3 local providers: East Kent Hospitals University Foundation Trust (EKHUFT), Kent and Medway NHS Partnership Trust (KMPT) and Kent Community Healthcare NHS Foundation Trust (KCHFT). The CCG also commissions other services: for example from South East Coast Ambulance (SECAmb); tertiary providers such as, Guys and St Thomas Hospital and Kings College Hospital; and an out of hours' service from IC24.

Hosting arrangements are in place with:

- Canterbury and Coastal CCG for the Financial Services Team.
- Kent and Medway NHS Partnership Trust for Payroll Services.
- South East Commissioning Support Unit (SECSU) for HR and Contract Support Services.
- Shared Business Services (SBS) for managing the general ledger.
- South Kent Coast CCG for shared staff and mental health commissioning support.
- Thanet CCG hosts the Children's Commissioning Support Team.

In addition, The CCG has entered into collaborative agreements with Kent County Council (KCC) and with other CCGs to share responsibility for the provision of services.

NHS England Assessment

NHS England's assessment of the CCG's performance at the end of March 2016 was overall assessed as "Assured with Support". This was made up of two ratings: "Assured as Good" in relation to Financial Management and Performance but "Limited Assurance: Requires Improvement" because our acute Trust has failed to meet significant constitutional and access standards, particularly Accident and Emergency 4 hour waits, 62 day cancer waits and referral to treatment within 18 weeks.

Performance Analysis

Measuring our performance

The CCG set targets for itself to monitor its performance. In addition, the CCG holds the providers to account for delivery against the Constitutional/Access standards set by Department of Health.

MEASURE	2015/16 PERFORMANCE	TARGET	COMMENT
In Hospital			
% A&E patients seen, treated, admitted or discharged within 4 hours	86.3%	95%	Data is for EKHUFT as a whole, not just Thanet CCG patients. As has been seen across the country EKHUFT has struggled to meet the 4 hour target. A contract performance notice has been in place and remedial action plans are being implemented. Recent developments include Thanet CCG working with staff at QEQM to understand issues at the site and inform improvements within primary and secondary care. This has involved the implementation of organisational change within QEQM which is being monitored monthly at a specific QEQM A&E meeting.
% patients waiting under 18 weeks between referral to treatment	89%	92%	Performance improved to 92% in October but has declined since. A contract performance notice has been in place with EKHUFT and remedial action plans are being monitored. An improvement trajectory has been agreed as part of the planning process with the expectation that compliance will be achieved in September 2016. The CCG has commissioned sufficient activity for 2016/17 to meet anticipated demand and achieve the RTT standard.

% cancer patients waiting under 62 days from referral to treatment	72%	85%	Performance has been consistently below the standard and EKHUFT is subject to a contract performance notice. Remedial actions are underway and an improvement trajectory has been agreed which forecasts compliance by June 2016.
Out of Hospital			
MRSA pre 48hrs	1	0	One case in August, occurred in an elderly gentleman in a care home. The post infection review panel identified the following actions: • Supporting residential care home staff to identify and manage symptoms of deterioration in service users. • Ensuring clinician involvement in planning and implementing EOL care plans. • Communication with out of hours providers and emergency services to ensure appropriate decisions are made. These actions have been shared with the relevant providers.
Dementia diagnosis rate	61.1%	67%	Dementia diagnosis rates improved steadily throughout the year and the CCG implemented innovative schemes to try to identify patients, these included visits to care homes by a consultant psychiatrist. The focus continues to be on particular practices, but care home work suggests that the estimated dementia prevalence for Thanet may be overstated.
% inpatients on CPA followed up within 7 days	93.8%	96.9%	Performance is monitored monthly through contractual meetings with KMPT. Concerns have been raised that a large proportion of patients who aren't on CPA are not followed up within 7 days and the intention is to

			monitor improvement over 2016-17.
IAPT: % of patients accessing IAPT	25%	15%	Access rates have been consistently high in Thanet.
IAPT: % of patients moving to recovery	49.2%	50%	A slight dip in performance this year. This is being investigated, but some indication that some of the patients being treated should not be accepted by IAPT providers as they require a broader package of care. This is being discussed with the new IAPT providers to ensure patients receive the most appropriate care for them. Progress continues to be monitored with IAPT providers on a monthly basis.
IAPT: % of patients entering treatment within 6 weeks of referral	67.7%	75%	This was a new indicator in 2015/16 and local data was not initially available. More recently, with local data now available, one particular provider is struggling to meet the standard. There is a suggestion that patient choice is affecting performance more significantly in Thanet than it does in other areas and this is being investigated.
IAPT: % of patients entering treatment within 18 weeks of referral	99.4%	95%	Performance against this new indicator has been in excess of the standard.
% of adults referred with a first episode of psychosis who receive treatment from EIP services within 2 weeks of referral	Data not available	50%	KMPT is currently unable to report performance. This is partly due to technical issues with data systems but also because KMPT EIP treatment does not meet the NICE guidelines. Reporting is expected to commence in 2016/17. This will be monitored closely as through monthly contractual meetings.

Financial performance		
QIPP	75.8%	The CCG QIPP achievement allowed it to meet its statutory requirements to produce a 1% surplus.
Better Care Fund (BCF) metrics	Thanet CCG has met planned reduction in admissions to residential and nursing care homes, and improvement in patients feeling supported to manage their conditions. Non elective admission rates, delayed transfers of care and injuries due to falls have not shown expected levels of improvement.	

Improving quality

Central to our strategic approach is the ambition to deliver quality related improvement whilst reducing spend. There is commitment across the local health and social care system to develop and deliver integrated care via a new model of care that ensures alignment of commissioner and provider plans. The areas of attention will be:

- Focus on specific health needs and areas of pressure identified in our strategy
- Support the level of integration we expect between our hospital and out of hospital service providers
- Support the system change we require to make the local health system fit for the future.

The areas of focus to help the CCG to achieve this include:

Respiratory	Over 75 years with LTC	Diabetes	CVD
Work collaboratively to embed and measure performance of new integrated care pathway for COPD patients, with ultimate aims being to; • Reduce non-elective admission / re-admission By; • Delivering care close to home • Improving transfer of care • Improving self-management	Embed and measure performance, with ultimate aims being to; • Develop a collaborative shared care plan approach • Improve transfer of care between providers • Improve the safety and quality of patient care	Embed and measure performance, with ultimate aims being to; • Reduce non-elective admission / re-admission By; • Delivering care close to home • Improving transfer of care • Improving self-management	Work collaboratively to embed and measure performance of new integrated care pathway for Heart Failure patients, with ultimate aims being to; • Reduce non-elective admission / re-admission By; • Delivering care close to home • Improving transfer of care • Improving self-management

Parity of Esteem

To further support our strategic ambition to close the gap between mental and physical health, we have devised 3 local quality incentives with our main mental health service provider, Kent and Medway Partnership Trust (KMPT). The quality incentives will;

- Focus on specific health needs and areas of pressure identified in our strategy
- Support the level of integration we expect between our hospital and out of hospital service providers
- Support the system change we require to make the local health system fit for the future

Focus within mental health includes:

Transition from adolescent to Adult Mental Health care	Dementia	Crisis Plans
Full implementation of safe effective transition pathway for adolescence from CAMHS to adult mental health services	Full implementation of ratified multi-agency integrated pathway for patients with Dementia	Full implementation of agreed % crisis plans across key acute cluster pathways. Reduced crisis episodes and unplanned admissions

Improving the quality of services and patient experience is a key issue in all we do. We formally monitor the quality and performance of the services we commission so that we can provide assurances to the Governing Body about the safety of commissioned services, During the year, we undertook a Deep Dive into Accident and Emergency at the local acute hospital, the outcome of which was reported to the Governing Body. The Quality and Operational Leadership Team reviews Serious Incidents and Never Events to identify whether adequate learning has taken place before agreeing to close the incidents. The HCAI assurance panel, a partnership of primary care, the CCG and the hospital has continued to review the most complex cases of Health Care Acquired Infections including C. Difficile and MRSA bacteraemia.

Sustainable Development

The CCG is required to report its progress in delivering against sustainable development indicators. The CCG continues to strive towards achieving its sustainable development aims and principles: Ensuring a strong, healthy and just society

- Living within environmental limits
- Achieving a sustainable economy
- Promoting good governance
- Using sound science responsibly

The CCG is looking to work towards developing a more joined up approach to health and social care and ensuring care is made available locally where possible. The Integrated Accountable Care Organisation (IACO) is a programme of work being developed that will see a more streamlined care pathway for the patient where care needs are able to be met simultaneously. It requires health and social care services to be organised locally so that they can work optimally together in designing integrated pathways which deliver the best outcomes and experiences for patients and offer best value for the tax payer.

Using the NHS Standard Contract, we require our providers to state how they are supporting sustainable development. The CCG is engaged, through the Health and Wellbeing Board and other local agencies, with resilience planning and creating a secure infrastructure that will help the local community remain sustainable when faced with sudden or disruptive events.

The CCG is committed to minimising, where possible, domestic waste while at the same time increasing recycling out-put. This is managed through the encouragement of a paperless office and other waste reduction initiatives such as food waste bins in offices. The CCG continues to support staff to adopt more sustainable ways of working, e.g. providing internet based meeting papers removing the requirement to print papers.

The CCG is continuing to look to implement a sustainability policy that will integrate sustainability considerations into all commissioning decisions by ensuring suppliers, partners and providers are aware of the sustainability policy and encouraging them to adopt appropriate sustainability management practices, e.g. through the tendering process and contract management.

We will develop plans to assess risks, enhance our performance and reduce our impact. We will ensure the Clinical Commissioning Group complies with its obligations under the Climate Change Act 2008, including the Adaptation Reporting power, and the Public Services (Social Value) Act 2012. In the coming year, we will identify how we can contribute to deliver the Sustainable Development Strategy published in February 2014 by NHS England. We will focus on how we can encourage our staff to adopt sustainable habits personally; and we will review how as an organisation the CCG can adopt sustainable approaches to its business.

We are also setting out our commitments as a socially responsible employer.

Public and Patient Engagement

The CCG has a statutory duty to involve patients and the public in commissioning planning and decisions (Section 14Z2 of the National Health Service Act 2006 as amended). We are also required to report on how we have fulfilled our public involvement duty which we do throughout the report but particularly in this section.

How Community Engagement Works

The CCG has a Lay Member for Patient and Public Involvement on the Governing Body. He reports to the Governing Body at every meeting and brings questions raised by the Health Reference Group.

Patient Participation Groups

Since 1 April 2015, it has been mandatory for each GP practice in England to have a patient participation group (PPG). Thanet CCG's Lay Member for Patient Engagement has contacted Thanet GP surgeries and has offered to meet each of their respective PPGs whose role is to:

- Provide a vital link between the CCG and local patients
- Co-ordinate views and issues from individual practice groups
- Working with the CCG to help plan and evaluate local health services

Health Reference Group

Thanet CCG has a collective reference group comprising representatives from the local GP surgery PPGs known as the Thanet Health Reference Group. This group meets on a quarterly basis to give the CCG direct feedback and support for its plans. So far they have discussed medicines management and how to reduce medicines waste, commissioning and the CCG's current priorities, and they have heard about self-care, personal health budgets (PHBs) and the stroke review.

The group also helps members to network and talk about their PPG activities in support of their GP practices, as well as highlighting any issues which their patients have reported about the wider health and social care services.

Public Meetings

Members of the public are welcome to attend any of the CCG Governing Body meetings held in public to ask questions. Special public events are also organised as required to discuss particular issues.

Redesigning Services with Patients

One of the ways that the public and patients help us is by getting involved at an early stage to give us their views about how we can improve the services we commission. In 2015/16 some examples of this include:

➢ Patient Transport Services

Thanet CCG has been working with the other clinical commissioning groups across

Kent and Medway to re-procure non urgent patient transport services. Forty-five Thanet patients helped to write the Patients' Charter setting out the measures of success people expect from the service and this has become part of the service specification which will be used to monitor and manage the new service. Thanet patients have also taken part in evaluating the tenders for the Kent and Medway patient transport service.

Talking Therapy Services

Thanet CCG, working with the other clinical commissioning groups in east Kent, re-procured talking therapy services which support patients with mild to moderate anxiety, depression and other common mental health problems. As part of this, the Mental Health Action Group and Health Reference Group for NHS Thanet Clinical Commissioning Group have reviewed the specification for the new service and contributed to the work of developing success criteria for it. The work was reported on to the Kent Health Overview and Scrutiny Committee. Service users were involved in the formal evaluation of the potential contractors and so informed the decision on which organisations to appoint.

Review of Wheelchair Services

This is looking at existing experience of services as well as gathering feedback on potential changes, ahead of re-procurement of the service in 2017. A survey has been conducted with people who use wheelchair services and their carers to ask about their experience of and views on the service they have received. A total of 129 responses were received and feedback highlights the following themes:

Review of Wheelchair services: Survey results	
Service	• The majority were positive about the wheelchair service overall citing efficient service, quick assessments and good customer care. • 32% of respondents experienced a delay of more than two months for assessment 61% of those experiencing a delay were not aware of the reason for it. Whilst 54% indicate 'no delay' for service on a

		wheelchair . There was as feeling that we "Need more wheelchair assessors."
Orders	•	68% of respondents support the orders being prioritised by date and postural/pressure care needs.
Referrals	•	64% of respondents support the possibility of stopping self-referrals for those who already have wheelchairs.
	•	support for implementation of a three strike rule wherby if patients do not turn up three times, they cannot self-refer again.

This feedback will be used in the specification for the re-procurement of the service this year, and service users will again be part of the formal evaluation of bidders within the procurement process.

➢ Personal Health Budgets

Thanet CCG has this year involved a range of service users, carers and GP practices and voluntary organisations in developing plans to offer more people in Thanet a Personal Health Budget (PHB). In November approximately 30 people attended a workshop to share ideas on how the CCG and their partners could work together with local people to support self-care effectively and develop proposals to offer PHBs from April 2016. Learning from the national pilots was shared, with examples from patients who had received one elsewhere.

During the question and answer session some clear concerns emerged around:

- The scale of work around PHBs.
- The amount of money needed to support PHBs including the cost of running scheme, for example the broker service.
- Allocation of funds, and the potential for a phased approach.
- Concern that this shouldn't adversely affect the existing NHS services or the VCS.

There was also some warm approbation for the idea as an important tool for giving patients choice. Other points raised were that:

- Money should be targeted at mental health service.
- A review process is needed as peoples' needs change over time.
- As a means to overcome short term problems for patients and carers.

Mental health was chosen by a clear majority as the most important area of care to receive support from PHBs. It was agreed that a phased approach was best to manage the risks and develop a robust process.

There has been further work with service providers, patients and the public to help the CCG develop plans for delivery, looking at how to determine who would be eligible, the criteria to be used, and how to determine what people could use their PHB on. There was consensus about the need for a broad access to PHBs for service users, with clear support for individuals using the care programme approach to agree the purpose and outcomes expected by using a PHB. People felt strongly that PHB should be used to extend choice and considered as an addition to, rather than a replacement of, existing services or support. Real life case studies have been used to test people's perceptions and refine the CCG's plans which will be implemented in the new financial year.

All of these will be used to develop the proposals, which will be taken through the internal decision making process and planning in preparation for implementation later in the year.

Learning from Complaints

The CCG welcomes any feedback including complaints, comments or expressions of concern from local people about either our own service or the quality of the services we commission and view them as an opportunity for improvement.

The CCG has been working with our Commissioning Support Unit (CSU) to ensure that any 'lessons learned' are clearly identified when responding to complaints. Further work will be undertaken during 2016/17 to produce a robust monitoring process for the CCG to track that any changes recommended as a result of a complaint are indeed subsequently implemented.

The Quality and Operational Leadership Team receives a bi-monthly complaints report which highlights to them the nature of the complaints being received by the CCG as well as the numbers of complaints both received and closed during that timeframe. The committee also reviews a quarterly report, produced by the CCG's Performance Team, of those complaints received by our providers. This provides us with important intelligence which can be used to triangulate the information we have about providers' performance.

The CCG has continued to receive complaints about the delay in processing NHS Continuing Health Care (CHC) retrospective claims as the CCG still has a number of claims outstanding and further to this there have been additional delays with processing payments of those claims where eligibility has been established.

Reducing Inequalities

The CCG has a statutory responsibility to reduce inequalities, working with our Health and Wellbeing Board to do so. Reducing the impact of deprivation on the local population is a "golden thread" throughout the CCG's strategy. The CCG regularly reviews information reported through Right Care[3] tools such as the Atlas of Variation. Through the use of Right Care tools, the CCG has also identified areas where healthcare may not be as good as in other parts of the country:

- Poor outcomes for patients with cancer and circulatory disease, and care provided is costly;
- Care for patients with diabetes has better outcomes and is cheaper in other CCGs with a similar demographic;
- Care for gastrointestinal and neurological conditions is more expensive in Thanet than in other similar CCGs;
- High numbers of under 5 year-olds are being admitted to hospital;
- There are high rates of emergency admissions to hospital for people over 75 which are potentially avoidable;

[3] http://www.rightcare.nhs.uk/

- Significant rise in delayed transfers of care from hospital.

The Thanet Health and Wellbeing Board has made reducing inequalities a priority and has established an inequalities sub-group to address the issues. This group is clinically led and includes commissioners and providers from across the system. The Group is using Right Care data to develop an action plan which will deliver solutions for the areas of greatest inequality in Thanet.

A cancer strategy and action plan have already been developed and a key focus is improving the uptake of screening. Providers of lifestyle services will offer greater support in certain deprived areas, such as Cliftonville and Newington, to promote healthier lifestyles. A campaign targeting those in the most deprived communities who have the poorest outcomes relating to cancer is also planned.

Hazel Carpenter
Accounting Officer
25 May 2016

Accountability Report

I. Members Report

NHS Thanet Clinical Commissioning Group (CCG) was established in April 2013 under the Health and Social Care Act 2012 as a body corporate.

How the CCG Works: Our Business Model

There are 17 Member Practices belonging to Thanet CCG following the closures of both Cecil Square surgery in September 2015 and Osbourne Road surgery in December 2015. Additional changes in 2015/16 included a change of name for The Albion Surgery which is now known as the Broadway Medical Practice from August 2015.

1. Bethesda Medical Centre	2. Birchington Medical Centre
3. Broadway Medical Practice	4. Dashwood Medical Centre
5. East Cliff Medical Practice	6. Garlinge Surgery
7. Minster Surgery	8. Mocketts Wood Surgery
9. Newington Rd Surgery	10. Northdown
11. St Peter's Surgery	12. Summerhill Surgery
13. The Grange Medical Centre	14. The Limes
15. Union Row Surgery	16. Westgate Surgery
17. Wickham Surgery	

For Further details, please see NHS Thanet CCG's website: www.thanetccg.nhs.uk

Governing Body Members

Dr Tony Martin has been chair of the CCG since it was established, up to and including the time of signing the Report and Accounts. Hazel Carpenter has been the Accountable Officer for the same period.

NHS Thanet CCG's Governing Body has a very strong clinical membership and focus, with a GP as Chair and five additional elected GP Governing Body members, along with a hospital consultant and a nurse member. The Governing Body also includes two independent lay members, and senior members of the CCG management team.

The following have been members of the NHS Thanet CCG up to and including the time of signing of the accounts unless otherwise indicated:

Dr Tony Martin	**Clinical Chair**
Hazel Carpenter	**Accountable Officer**
Jonathan Bates	**Chief Finance Officer**
Dr Mark Elliott	**GP member**
DrJihad Malasi (from 1 Jan 2016)	**GP member**
Dr Adem Akyol	**GP member**
Dr Tariq Rahman (until Nov 2015)	**GP member**
Dr John Neden	**GP member**
Dr Sabin Kamal (from Nov 2015)	**GP member**
Dr Devaka Fernando	**Secondary Care Doctor**
David Lewis	**Lay member with responsibility for Governance**
Clive Hart	**Lay member with responsibility for Public Engagement**
Sharon Gardner-Blatch	**Chief Nursing Officer**

Details of the senior management team are outlined below:

Hazel Carpenter	**Accountable Officer**
Jonathan Bates	**Chief Finance Officer**
Ailsa Ogilvie	**Chief Operating Officer**
Dr Sue Martin	**Company Secretary**

See page 69 for biographies of the Governing Body members.

The Governing Body has a number of committees to help conduct its business. Their responsibilities are set out in the Constitution and summarised in the Annual Governance Statement by the Accountable Officer.

Compliance Statements

Responsibility for Audit

The Governance and Risk Committee discharges the responsibility of an audit committee. The following have been members of the Governance and Risk Committee in Thanet up to and including the time of signing the accounts:

David Lewis	**Chair, Lay Member for Governance and Risk**
Clive Hart	**Lay Member for Patient Engagement**
Alistair Smith	**Independent Co-opted Member**
Stewart Coltart	**Secondary Care Doctor**

The external auditors, Grant Thornton, and the internal auditors, Tiaa Ltd both attend the Governance and Risk Committee and regularly meet separately with the members of the Committee.

External Audit

The Audit Commission appointed Grant Thornton as the external auditors of the CCG. The contract value for this work is £55,620 for 2015/16

Statement as to Disclosure to Auditors

The Governing Body delegated responsibility for approving the Annual Report and Accounts to the Governance and Risk Committee. Each Member of the Governance and Risk Committee has stated, confirmed by the minutes that as far as they are aware there is no relevant audit information of which the CCG's auditors are unaware. Each Member has taken all steps that they think necessary as a member of the Governing Body and the Governance and Risk Committee to make themselves aware of any relevant audit information and establish that the CCG's auditors are aware of that information. This was confirmed by the Governing Body Members at the meeting of the Governing Body meeting on 10th May 2016.

Members Interests

The register of interest for Thanet CGG's Governing Body members can be found on our website; www.thanetccg.nhs.uk.

Pension Liabilities

The CCG provides pensions for staff and for GP Elected Members on the Governing Body under the NHS Pension scheme. This is a 'Pay as you earn' scheme and follows international accounting practice. The basis of the accounting treatment is set out in the statutory financial statement within the CCG's accounting policies section of the accounts.

Control measures are in place to ensure all employer obligations contained within the scheme regulations are complied with. This includes ensuring that deductions from salary, employer's contributions and payments into the scheme are in accordance with the scheme rules, and that member pension scheme records are accurately updated in accordance with the timescales detailed in the regulations.

Equality, Diversity & Human Rights Obligations

The CCG acknowledges its responsibilities under the Equality Act 2010 and the Human Rights Act 1998 and associated equality legislation. It strives to:

- eliminate discrimination, harassment and victimisation and any other conduct that is prohibited by or under the Equality Act
- advance equality of opportunity between people who share a relevant protected characteristic and people who do not share it
- foster good relations between people who share a relevant protected characteristic and those who do not share it

The CCG has policies in place to ensure that there is no discrimination of any individual or group on the grounds of age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex, and sexual orientation.

The CCG is also required to publish information demonstrating its compliance with the general duty by 31st January each year and will also publish one or more equality objectives by 6th April each year.

Data Protection: Cost Allocatlon and Setting of Charges for Information

The CCG has received one Subject Access Request under the Data Protection Act, however this was for records for which the CCG is not the Data Controller and therefore we were unable to comply with this request. We certify that the CCG is aware of HM Treasury's guidance on cost allocation and the setting of charges for information however, the CCG will rarely apply charges as the amounts are considered too small to offset against raising an invoice.

Disclosure of Personal Data Related Incidents

The CCG has a policy for dealing with Serious Untoward Incidents in its Risk Management Policy. The CCG uses the IG Toolkit Incident Reporting Tool to report IG SIRIs to the Health and Social Care Information Centre (HSCIC), Department of Health, ICO and other regulators. In the Annual Governance Statement, the Accountable Officer has declared that there were no Serious Untoward Incidents in 15/16.

Health and Safety

The SECSU provides Health and Safety support to the CCG and has responsibility for the annual review of the CCG's premises at Thanet District Council to ensure compliance with statutory guidelines.

The CCG's Health and Safety Adviser also undertakes desk assessments for all new members of staff, and then as required by all staff. They will attend the Staff Engagement Forum to report regularly on developments and issues relating to health and safety.

There has been one accident reported at work during 2015/16.

Counter Fraud

NHS Thanet CCG has an Anti-Fraud Bribery and Corruption Policy. In 2015 TIAA Ltd, the internal auditors, conducted another benchmarking survey amongst staff about awareness of fraud and whistleblowing which showed a relatively good response. However, further training is needed to improve awareness of how to go about raising a concern.

The counter fraud exercise to ensure the information on all staff files is up-to-date continued throughout 2015/16, this required all staff to meet with the Counter Fraud Support Officer who made relevant checks to ID and documentation.

Better Payments Practice Code

The Better Payment Practice Code requires the CCG to aim to pay all valid invoices by the due date or within 30 days of receipt of a valid invoice, whichever is later.

On 1 April 2013 the CCG became an approved signatory of The Better Payment Practice Code. The initiative was devised by the government with The Institute of Credit Management (ICM) to tackle the crucial issue of late payment and to help small businesses. Suppliers can have confidence in any company that signs up to the code that they will be paid within clearly defined terms, and that there is a proper process for dealing with any payments that are in dispute.

Approved signatories undertake to:

- Pay suppliers on time.
- Give clear guidance to suppliers and resolve disputes as quickly as possible.
- Encourage suppliers and customers to sign up to the code.

Details of the compliance with the code are given in note 6.1 to the accounts.

In 2015/16 compliance with the Code was as follows:

	Number of invoices	Value of invoices
Non NHS	96%	98%
NHS	98%	99%

Prompt Payments Code

Thanet CCG has also signed up to the prompt payment code.

Emergency Preparedness, Resilience and Response

The CCG has in place incident response plans and business continuity plans to ensure its business can continue in the event of a major emergency. The CCG is a member of the Local Health Resilience Forum and the Kent Resilience Forum. The CCG has taken part in a number of exercises to ensure it is prepared for emergencies. It engages with partners to review its response to emergencies including health protection incidents and flu pandemics.

We confirm that the CCG has an updated incident response plan in place that was approved by the Governing Body in December 2015 and is fully compliant with the NHS Commissioning Board Emergency Preparedness Framework 2013. The CCG regularly reviews and makes improvements to its major incident plan and has a programme for regularly testing the plan, the results of which are reported to the Governing Body.

Principles for Remedy

As part of its complaints procedures, the CCG has set out the steps it will take should it cause injustice or hardship by maladministration or by service failure. The steps are as follows:

- The CCG will acknowledge and put right cases of maladministration or poor service that have led to injustice or hardship.
- The CCG will apologise for and explain the maladministration or poor service and understand and manage people's expectations and needs.
- The CCG will be open and clear about how public bodies decide remedies, operating a proper system of accountability and delegation in providing remedies.
- The CCG will offer remedies that are fair and proportionate to the complainant's injustice or hardship and provide remedy to others who have suffered injustice or hardship as a result of the maladministration.
- The CCG will, if possible, return the complainant and where appropriate others who have suffered similar injustices or hardship to the position they would have been if the maladministration or poor service had not happened.
- The CCG will use the lessons learned from the complaints to ensure that maladministration or poor service is not repeated and services are improved.

ACCOUNTABILITY REPORT – CORPORATE GOVERNANCE REPORT

I.STATEMENTS BY THE ACCOUNTABLE OFFICER

Statement of the Responsibilities as the Accountable Officer of NHS Thanet Clinical Commissioning Group

The NHS Act 2006 as amended states that each Clinical Commissioning Group shall have an Accountable Officer and that Officer shall be appointed by the NHS Commissioning Board (NHS England). NHS England has appointed Hazel Carpenter to be the Accountable Officer of the Clinical Commissioning Group.

The responsibilities of an Accountable Officer, including responsibilities for the propriety and regularity of the public finances for which the Accountable Officer is answerable, for keeping proper accounting records (which disclose with reasonable accuracy at any time the financial position of the Clinical Commissioning Group and enable them to ensure that the accounts comply with the requirements of the Accounts Direction) and for safeguarding the Clinical Commissioning Group's assets (and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities), are set out in the *Clinical Commissioning Group Accountable Officer Memorandum* published by NHS England.

Under the NHS Act 2006 (as amended), NHS England has directed each Clinical Commissioning Group to prepare for each financial year financial statements in the form and on the basis set out in the Accounts Direction. The financial statements are prepared on an accruals basis and must give a true and fair view of the state of affairs of the Clinical Commissioning Group and of its net expenditure, changes in taxpayers' equity and cash flows for the financial year.

In preparing the financial statements, the Accountable Officer is required to comply with the requirements of the Government's Manual for Accounts and in particular to:

- Observe the Accounts Direction issued by NHS England, including the relevant accounting and disclosure requirements, and apply suitable accounting policies on a consistent basis;
- Make judgements and estimates on a reasonable basis;
- State whether applicable accounting standards as set out in the Manual for Accounts have been followed, and disclose and explain any material departures in the financial statements; and,
- Prepare the financial statements on a going concern basis.

To the best of my knowledge and belief, I have properly discharged the responsibilities set out in NHS England's *Clinical Commissioning Group Accountable Officer Memorandum*.

Hazel Carpenter
Accountable Officer
25 May 2016

III.ANNUAL GOVERNANCE STATEMENT: 2015/16

The Thanet Clinical Commissioning Group was licensed from 1 April 2013 under provisions enacted in the Health & Social Care Act 2012, which amended the National Health Service Act 2006.

As at 1 April 2015, the Clinical Commissioning Group (CCG) was rated as “assured with support” by NHS England (NHSE). NHSE has concluded that the CCG continued to make steady progress and was able to articulate a clear 5 year vision and good engagement with local people. However, it required the CCG to keep pressure on the local providers whose continued poor performance continued to compromise high quality services and better outcomes for local people. The performance of its providers continues to be a challenge for the CCG. At this point, the members of the CCG have decided not to undertake co-commissioning of primary care services but will keep this decision under review.

Scope of Responsibility

As Accountable Officer, I have responsibility for maintaining a sound system of internal control that supports the achievement of the CCG’s policies, aims and objectives, whilst safeguarding the public funds and assets for which I am personally responsible, in accordance with the responsibilities assigned to me in *Managing Public Money*. I also acknowledge my responsibilities as set out in my CCG Accountable Officer Appointment Letter. I am responsible for ensuring that the clinical commissioning group is administered prudently and economically and that resources are applied efficiently and effectively, safeguarding financial propriety and regularity.

Compliance with the UK Corporate Governance Code

The CCG is not required to comply with the UK Corporate Governance Code. However, I have reported on our corporate governance arrangements by drawing upon best practice available, including those aspects of the UK Corporate Governance Code I consider to be relevant to the clinical commissioning group and best practice. During the year, the Governing Body reviewed how effectively it complied with its statutory responsibilities. The Governance and Risk Committee has undertaken a review of the CCG's governance using the Good Governance Institute Toolkit and will follow this up with a more detailed review in two specific areas in 2016/17 to ensure the CCG's governance arrangements continue to remain robust.

The Clinical Commissioning Group Governance Framework

The National Health Service Act 2006 (as amended), at paragraph 14L(2)(b) states:

The main function of the governing body is to ensure that the group has made appropriate arrangements for ensuring that it complies with such generally accepted principles of good governance as are relevant to it.

Our Constitution, which is published on our website, sets out the governance arrangements we have established for ensuring that we make decisions openly and transparently, based on an assessment of clinical need, for ensuring that we meet our financial and statutory obligations, and for ensuring that we manage and control risk effectively. The CCG's Constitution has been approved by NHS England. During 2015/16, parts of the Constitution were reviewed, including the terms of reference for all the Committees and the conflicts of interest policy. I have asked the Governance and Risk Committee to oversee further revisions to the Constitution during 2016/17 to ensure it remains fit for purpose for the future.

The Membership

The CCG is a membership organisation comprising the 17 General Practices in the area of Thanet (see Members' Report, Page 36). Each Member Practice has signed up to the Constitution of the CCG which sets out the Vision and Values of Thanet CCG and has agreed to participate actively in its work. Each Practice is represented by a Lead, a clinical professional, whose role is to represent the views of their Practice and act on the Practice's behalf in respect of matters discussed by the CCG.

During the year, the Members were asked to appoint a number of GP Elected Leads to represent them on the Governing Body and its committees. The Members meet as a Clinical Commissioning Group regularly throughout the year. At the Membership meetings, the Governing Body accounts to the membership for its implementation of the CCG's strategy and takes the members' views on important issues, including prescribing costs and the future of primary care in Thanet.

As well as providing strategic support to the organisation, the Members are actively involved in the activities of the CCG. In addition to the Governing Body members, there are several local GPs who actively engage with the CCG as clinical leads. They provide clinical leadership for aspects of the CCG's commissioning strategy, including (for example) mental health, primary care and children's health. It remains the members' responsibility to approve the CCG's strategy and engage with and listen to the perspectives of patients expressed through the Patient Participation Groups.

The Members have continued to guide the development of the CCG's approach to the Integrated Accountable Care Organisation, as part of which four localities have been established, in Margate, Ramsgate, Broadstairs and Quex. In each locality, the members are involved in redesigning services at a local level to ensure that care is wrapped round the patient. At the end of 2015 it was announced that Thanet had successfully bid to become one of the fifteen national rapid test sites for the Primary Care Home - a form of multispecialty community provider (MCP) model. More information about the localities is included at page 16.

The Governing Body

The Governing Body is tasked by the Members with ensuring that the CCG has adequate arrangements in place to deliver the CCG's strategic direction, to monitor its performance and to meet its statutory responsibilities. All Governing Body Members have equal and joint responsibility for governing the activities of the CCG and in being accountable to the Membership and the public for the way in which it discharges its functions.

The CCG's scheme of delegation and Committee Terms of Reference set out the level of delegation to the Governing Body from the Membership.

The Governing Body met 3 times during 2015/16 in public and 5 times in private session. At its meetings, the Governing Body

- Continued to refine the priorities in the Thanet Plan and to monitor its implementation.
- Scrutinised the performance of the CCG'S main providers including the quality of primary care through a primary care dashboard.
- Regularly discussed the development of the Integrated Care Organisation and the Health and Wellbeing Board, both of which are vital to the CCG's future strategy.
- Approved several procurement exercises, including for Integrated Community Equipment Store, Patient Transport Service and the Out of Hours/111 NHS and Care Navigation service.
- Heard regularly about engagement activities with local people and with the membership and used these reports to underpin its decision-making processes.
- Approved key CCG documents including the Risk Management Policy, the Whistleblowing Policy, revised terms of reference for its committees, and kept the Risk Register and Assurance Framework under review.
- Received reports of the CCG's partnerships with the Kent Health and Wellbeing Board; the East Kent System Resilience Group, the East Kent Strategy Board and the East Kent Federation; and the Thanet Health and Wellbeing Board.

The membership of the Governing Body is included in the Members' Report. I report on their attendance at Governing Body meetings below. Dr Joseph Braga was appointed to the Governing Body for 1st April 2015 but was unable to take up his appointment. Dr Tariq

Rahman stood down in November 2015. Two new members were appointed to replace both: Dr Sabin Kamal and Dr Jihad Malasi who took up their roles on 1 November and 1st January 2016 respectively.

Thanet Governing Body Members' Attendance at Public Meetings

GB MEMBER	14/07/15	08/12/15	08/03/16	TOTAL
Tony Martin	√	√	√	3/3
Hazel Carpenter	√	√	√	3/3
Jonathan Bates	√	√	√	3/3
Devaka Fernando		√	√	2/3
Mark Elliott	√	√	√	3/3
Sabin Kamal (from 1 November 2015)		√	√	2/2
Adem Akyol	√	√	√	3/3
Tariq Rahman (until 13 November 2015)				0/2
David Lewis	√	√	√	3/3
Clive Hart	√	√	√	3/3
Sharon Gardner-Blatch		√	√	2/3
John Neden	√	√	√	3/3
Jihad Milasi (from 1 January 2016)			√	1/1

All Governing Body members, CCG Members and members of staff are required to record annually any interests which are relevant to their role on the CCG. The register of interests is updated each quarter and is a public document on the CCG's website. During the year, we asked those in a position in GP practices to take decisions regarding expenditure and contracts to declare interests, which are also on the CCG's website. http://www.thanetccg.nhs.uk/home/#

Managing potential conflicts of interest is important because GPs as Governing Body members are involved in taking decisions about the provision of services, from which they may benefit as members of GP practices. The CCG has adopted a Code of Conduct for GPs relating to procurement where GP practices may also be providers of services. The CCG has revised the Conflicts of Interest policy to give the Governance and Risk Committee a larger role in monitoring the recording of interests, including by GP practices, and in monitoring decisions about procurement. It also provides advice to the Clinical Chair and Accountable Officer on how to manage interests so that the CCG can ensure that decisions about procurement are taken on a strong clinical basis, transparently and with the best interests of the local population in mind.

The CCG's Organisation Development Plan has concentrated on strengthening the wider clinical leadership of the CCG and improving the CCG's analysis of data in order to provide a more effective focus on performance.

The Clinical Chair has discussed the performance of the GP Elected Leads on the Governing Body throughout the year.

Committees of the Governing Body

The Committees established by the Governing Body are as follows:

- The Clinical Leadership Team
- Quality and Operational Leadership Team
- The Governance and Risk Committee
- The Remuneration and Nominations Committee.

The Clinical Leadership Team (CLT) met monthly during 2015/16. It has taken the lead role in overseeing the development and implementation of the strategic priorities in the Thanet Plan.

At every meeting the Committee has received an update about developments "In Hospital", and in Integrated Care (including primary care), mental health, dementia, children's services, public health and prescribing.

- CLT considered a number of key clinical issues, including cancer strategy, an update on stroke services, End of Life Pathway, CAMHS specification, Over 75s project and the project on Discharge to Assess.

The Committee reviewed its terms of reference and undertook an assessment of its effectiveness. It agreed that it covered the clinical issues well but wanted to be more forward looking in its discussions and to monitor the implementation of the key strategies which will enable the CCG to move forward.

Members of Clinical Leadership Team

NAME	ROLE	ATTENDANCE (out of 12 meetings)
Dr Tony Martin	Chair	12
Dr Adem Akyol	GP Member	11
Dr Mark Elliott	GP Member	8
Dr John Neden	GP Member	11
Dr Tariq Rahman	GP Member until 13 November 2015	5/8
Dr Sabin Kamal	GP Member from 1 November 2015	1/5
Dr Jihad Malasi	GP Member from 1 January 2016	1/3
Prof Devaka Fernando	Secondary Care Doctor	5
Hazel Carpenter	Accountable Officer	9
Jonathan Bates	Chief Finance Officer	6
Ailsa Ogilvie	Chief Operating Officer	10
Sharon Gardner-Blatch	Chief Nursing Officer	8
Colin Thompson	Public Health Consultant	9

The Quality and Operational Leadership Team (QOLT) also met on a monthly basis during 2015/16. Its focus was on monitoring the in-year performance of providers commissioned by the CCG and of the CCG itself. The Committee:

- Reviews the management of risks and the CCG's financial position and receives regular reports on complaints, safeguarding adults and children, Looked After Children and Transforming Care.
- Has lead responsibility for reviewing safety and quality, considering patient experience, for closing Serious Incidents and reviewing "Never Events" to identify improvements and learning. During the year, the Committee gained the Governing Body's approval to establish a sub-group which reviews the Serious Incidents received by the CCG on the Committee's behalf. The Committee retains the decision as to whether a Serious Incident can be closed.
- Strengthened its oversight of provider quality and performance. The Integrated Quality and Performance Report (IQPR) has continued to highlight key performance and quality concerns and triangulate those concerns with other data for all the CCG's providers and the CCG's constitutional targets. It is a key tool enabling the Committee to identify issues which need to be raised with providers at an early stage so that the providers can address these.
- The intelligence in the IQPR has also informed the discussion in Contract Delivery meetings and in several instances has resulted in the issue of a Contract Query Notice to providers to improve performance. The Committee has been particularly concerned about the performance of A&E at Queen Elizabeth Queen Mother (QEQM) hospital and about the 62 day wait target for cancer. These are reported upon in the Performance section of the Annual Report (page 23). The data also informs the CCG's decisions to undertake quality visits and deep dives, for example, into maternity services and into A&E.
- Now reviews the performance of primary care using a primary care dashboard, and of nursing homes in the area.
- Has also reviewed its terms of reference and considered its effectiveness as a Committee in discharging its responsibilities. The Committee agreed that, to help it manage its very large agenda, it would establish a sub-group to review Serious Incidents in detail before they are presented to the Committee for decision on whether to close.

Members of Quality and Operational Leadership Team

NAME	ROLE	ATTENDANCE (out of 10 meetings)
Hazel Carpenter	Accountable Officer	9
Dr Tony Martin	Chair	7
Dr Adem Akyol	GP Member	5
Dr Mark Elliott	GP Member	9
Dr John Neden	GP Member	6
Dr Tariq Rahman	GP Member until 13 November 2015	0
Dr Sabin Kamal	GP Member from 1 November 2015	0/3
Dr Jihad Malasi	GP Member from 1 January 2016	3/3
David Lewis	Lay Member, Governance	10
Clive Hart	Lay Member, PPE	10
Jonathan Bates	Chief Finance Officer	8
Ailsa Ogilvie	Chief Operating Officer	5
Sharon Gardner-Blatch	Chief Nursing Officer	6
Louise Pilcher	Practice Manager	3/6
Dr Sue Martin	Company Secretary	10

The **Governance and Risk Committee** is charged with providing independent assurance to the Governing Body that the CCG's systems of risk management, internal control and governance are effective. These include the CCG's arrangements for preventing corruption and for countering fraud.

The Governance and Risk Committee has met jointly with the NHS South Kent Coast CCG Governance and Risk Committee 5 times during 2015/16. The Committee is alternately chaired by the Lay Member for Governance of each CCG.

The Lay Member for Public and Patient Engagement is a member of the Committee as is the secondary care doctor for South Kent Coast CCG. The Committee meetings are attended by the External Auditors, the Internal Auditors, the Chief Finance Officer, the Chief Nursing Officer and the Company Secretary.

The Committee Chair has financial expertise and the Chief Nursing Officer and the Secondary Care Doctor provide expertise in clinical effectiveness and quality.

- The Committee has performed a number of key tasks at my request, providing assurance to me through their independent scrutiny and challenge. I asked the Committee to keep the CCG's arrangements for providing assurance to NHS England under review. The Chair of the Committee completed several submissions required by NHS England, including an assessment of the CCG's financial control environment.

- The Committee's annual work plan has been approved by the Governing Body. The Committee reviewed a number of policies before these were submitted to the Governing Body for approval, including the risk management policy, the whistleblowing policy and gifts and hospitality policy.

- It reviewed the operation of the Conflicts of Interest Policy, the use of Single Tender Waivers and undertook a review of a contracting exercise on DVT. As a result of each of these reviews, the Committee made recommendations for improvement to the Governing Body.

- The Committee reviewed the risk register and assurance framework at each meeting and heard regularly from the internal auditors, Tiaa Ltd, who have responsibility for advising the Committee on whether the control arrangements which the CCG has in place are adequate. The Committee also received reports from the Counter Fraud Service.
- The Committee received reports from the external auditors, Grant Thornton, who are required to perform the CCG's audit and in accordance with the Code of Practice issued by the National Audit Office (NAO) on behalf of the Comptroller and Auditor General in April 2015. The external auditors' responsibilities under the Code are to:
  - give an opinion on the CCG's financial statements
  - give an opinion on the regularity of expenditure and income recorded in the CCG's financial statements
  - satisfy themselves that the CCG has made proper arrangements for securing economy, efficiency and effectiveness in its use of resources

based on the following criterion: In all significant respects, the audited body had proper arrangements to ensure it took properly informed decisions and deployed resources to achieve planned and sustainable outcomes for taxpayers and local people.

The Governance and Risk Committee reviewed its terms of reference and undertook a review of its effectiveness as a Committee. The Committee concluded that it was working reasonably well, but there was also consensus about some areas for improvement, included ensuring that the accounting policies were reviewed as part of the annual accounts process. They submitted an annual report to the Governing Body which is published on the CCG's website.

Governance and Risk Committee Members

MEMBER	ROLE	ATTENDANCE (out of 5 meetings)
David Lewis	Committee Chair	5
Clive Hart	Lay Member PPE	5
Alistair Smith	Co-opted Lay Member	5
Dr Stewart Coltart	Co-opted Secondary Care Doctor	5

The **Remuneration and Nominations Committee** has met three times during 2015/16. The Committee has responsibility for making recommendations to the Governing Body on remuneration of members of the Governing Body and senior employees of the CCG, advising on contractual arrangements for the same group of people, developing an approach to succession planning and ensuring that the Governing Body has the right balance of skills and knowledge. It is chaired by the Lay Member for Governance.

The Committee

- Heard from the Clinical Chair about the effectiveness of the clinical members of the Governing Body and from myself as Accountable Officer on the performance of senior members of the CCG staff
- Reviewed the rates of pay for the Governing Body
- Agreed the training which would be mandatory for Governing Body members
- Considered succession planning including the skills needed on the Governing Body
- Reviewed its terms of reference
-

Remuneration Committee Members

MEMBER	ROLE	ATTENDANCE (out of 3 meetings)
David Lewis	Committee Chair	3
Clive Hart	Lay Member PPE	3
Tony Martin	Clinical Chair	3

Joint Committees

The CCG has not established a Joint Committee.

The CCG's Risk Management Framework

Key elements of the risk management strategy

The purpose of the CCG's Risk Management framework is to enable the CCG to have a clear view of the risks affecting each strand of its activity and how they should be managed.

The CCG's Risk Management Policy, which sets out responsibilities for identifying and managing risk as well as the arrangements the CCG has in place for opening, rating and closing risks, was reviewed and updated during the year. The Governing Body has overall responsibility for managing risks and assurance and reviews those risks which are rated "red". The Clinical Leads help to identify risks in relation to their clinical area, to design mitigating actions and to ensure that risks are appropriately managed. The Quality and Operational Leadership Team regularly reviews the management of the most significant clinical risks using both the Risk Register and the Integrated Quality and Performance Report. The Governance and Risk Committee is responsible for providing assurance to the Governing Body on the effectiveness of risk management.

The CCG has policies and processes in place to prevent certain risks emerging in the first place, for example through its counter fraud policy, its bribery policy and statement of standards of business conduct, which was reviewed during the year. The CCG's whistleblowing policy provides an opportunity for anyone who has a concern about the conduct of the CCG to raise a concern without fear of repercussions. Governing Body Members are required to declare any conflicts of interest at each meeting. The CCG provides training on its policies and the Counter Fraud specialist from the Internal Auditors reports regularly to the Governance and Risk Committee.

Risk assessment

The CCG has focused more clearly on how risks impact on any one of its strategic objectives. The risk register shows links to the strategic objectives and to the Assurance Framework. Once identified, risks are rated in terms of the likelihood of their occurrence and their impact if they did, using the 5x5 matrix; they are reassessed once the mitigating actions have been identified, leaving the risk score showing the residual risk level to the CCG. A decision is made as to whether the risk can be tolerated or must be treated. If it is to be treated, additional mitigating actions are identified and monitored so that the risk level can be reduced to a tolerable level.

In discussing its appetite for risk, the CCG Governing Body has stated that it has no tolerance for risks where patient safety is at issue, where the ongoing financial viability of the CCG is at issue, or where the CCG's compliance with the law may be adversely affected. The level of risk which can be tolerated in delivering its strategic objectives does vary; for example, the Governing Body is willing to accept a level of risk to promote innovation or where long-term benefits outweigh short term risks; but the CCG scrutinises the level of risk regularly and challenges whether the risk has reduced or why it has remained at the same level for some time.

To help the CCG manage risks, the CCG values the contributions of local people. The CCG monitors complaints made by the public about its services and those of the local providers. It conducts regular discussions and consultations with local people about their experience of health services and involves them in the redesign of services. For example, Thanet hosted a number of discussions with local people on the reconfiguration of stroke services. Local people are able to ask questions and alert the CCG to any risks at the Health Reference Group and at the Governing Body meetings.

The most significant risks identified by the CCG during 2015/16 were:

RISK	ACTION
High number of Looked After Children in Thanet not receiving their statutory health assessments in a timely way. Monitoring provision of services is difficult because of lack of performance data.	The CCG has escalated its concern about the poor performance of providers through issuing a Contract Performance Notice, requiring the providers to detail how they will improve.
The high use of out of area mental health beds results in poor patient experience and increased costs	This risk is being managed through bi-weekly telephone discussions with the provider to find alternatives to out of area placements.
The acute trust has continued to fail to meet constitutional targets, including A&E 4 hour waits, Referral to Treatment in 18 weeks and 62 day cancer wait.	The CCG is working with other CCGs in East Kent to address these performance issues, but has instigated detailed reviews, including by its GP members, to identify where the problems are. This will continue to be a risk in the coming year.
The financial position of the CCG and all the providers in the East	The CCG is addressing this risk through a savings action plan which is monitored

Kent health economy. The CCG has identified a number of high risk areas in its own expenditure, including Continuing Health Care Placements and GP prescribing costs, which it is monitoring. The providers in East Kent face significant deficits which will make achieving agreements about contracts challenging	at every meeting of the Governing Body and the Quality and Operational Leadership Team, monitoring the performance of GPs particularly around prescribing expenditure and working closely with the providers on affordable secondary care strategies, highlighting areas where productivity needs to improve. Where appropriate, the CCG has also put in place formal dispute arrangements for key areas of financial pressure

Other risks are on-going. Due to the profile of the population of Thanet, there are particular challenges which Thanet CCG must address. Of the twelve local authorities in Kent, Thanet is the most disadvantaged. The percentage of the population aged over 65 is high and expected to grow, while at the same time the number of children born in Thanet is increasing. There are high levels of substance and alcohol abuse and high demand for mental health services including for children and older people at a time when the economically productive proportion of the population is declining, all of which make for particular challenges not only for the CCG but for its partners such as the County Council and District Council. The CCG is addressing these challenges by working in partnership particularly with the Thanet District Council and other members of the local Health and Wellbeing Board and agreeing joint strategies for addressing the major issues of inequalities, cancer, and obesity.

The principal risk to the CCG's governance for the coming year is that of the CCG's Constitution keeping pace with the development of greater localism. In line with the NHS Five Year Forward View, the CCG is considering how to achieve more integrated commissioning and more devolved and community based delivery of services. These developments may challenge the scope of delegation currently permitted by NHS England. However, we are in regular discussion with NHSE about our plans and identifying issues where current arrangements constrain our ability to deliver the CCG's vision.

The CCG has improved its analysis of risk and its impact and I expect this to continue in the next year. During 2015/16, steps have been taken to ensure that all Members and staff are aware of how the CCG defines risk and that risk is properly assessed and managed. The CCG discusses partner/provider risks at performance meetings and when negotiating agreements such as s75 agreements.

The CCG's Internal Control Framework

A system of internal control is the set of processes and procedures in place in the CCG to ensure it delivers its policies, aims and objectives. It is designed to identify and prioritise the risks, to evaluate the likelihood of those risks being realised and the impact should they be realised, and to manage them efficiently, effectively and economically. The system of internal control allows risk to be managed to a reasonable level rather than eliminating all risk; it can therefore only provide reasonable and not absolute assurance of effectiveness.

The CCG's system of internal control is a significant part of the assurance framework and is designed to manage risk at a reasonable level. This is particularly important as a number of risks which might undermine the CCG's delivery of its plans are "owned" by providers of services, not directly by the CCG. The Assurance Framework records the primary risks to the ongoing viability of the CCG: the risk of not delivering its strategic objectives, not meeting its financial targets, not delivering the CCG's statutory requirements, not commissioning safe services, not maintaining its authorisation, and not maintaining the support of the CCG membership and the public. The Assurance Framework evaluates the strength of the internal controls in preventing the risk materialising, and identifies gaps in assurance.

The Assurance Framework has been used by the Governing Body to hear from and challenge the Clinical Leads about progress in delivering the objective for which they are accountable. The Assurance Framework is also monitored by the Governance and Risk Committee, the Quality and Operational Leadership Team and the Governing Body.

Impact Assessments, including Equality Impact Assessments and Privacy Impact Assessments, help the Governing Body identify risks which might disproportionately affect various members of the community. Policies and business cases are expected to be presented to the Committee and Governing Body with an appropriate Impact Assessment, particularly an Equality Impact Assessment, to help with identification of risk. The strategies developed by the CCG in partnership, for example the Kent Health and Wellbeing Board's Emotional Wellbeing Strategy, also have an Equality Impact Assessment.

The CCG's policies relating to standards of business conduct make explicit the CCG's expectation that all members and staff will behave in an ethical manner. Internal audit plays a key role in monitoring the effectiveness of the CCG's internal control framework, and has undertaken reviews of critical financial systems, governance processes, and information governance. The Counter Fraud Officer also reviews the effectiveness of the CCG's procedures in preventing and identifying fraud.

The Performance Report contains statements about the CCG's compliance with a number of statutory duties which I have reviewed and which I confirm are correct (see page 67)

Information Governance

The NHS Information Governance Framework sets the processes and procedures by which the NHS handles information about patients and employees, in particular personal identifiable information. The NHS Information Governance Framework is supported by an information governance toolkit and the annual submission process provides assurances to the Clinical Commissioning Group, other organisations and to individuals that personal information is dealt with legally, securely, efficiently and effectively.

In April 2015, the CCG took over the management of its compliance with Information Governance requirements from the South East Commissioning Support Unit. We place high importance on ensuring there are robust information governance systems and processes in place to help protect patient and corporate information. We have established an Information Governance Management Framework and reviewed all the Information Governance policies. We have established an Information Governance Steering Group jointly with South Kent Coast CCG to oversee the completion of audits and reviews which will ensure that the CCG continues to develop information governance processes and procedures in line with the information governance toolkit. We have ensured all staff undertake annual information governance training and have developed information governance guidance for all staff to ensure staff are aware of their information governance roles and responsibilities. The Senior Information Risk Owner (SIRO) and the Caldicott Guardian have undertaken the training required for their roles.

There are processes in place for incident reporting and investigation of serious incidents. The CCG has not had any breaches of information security relating to the inappropriate release of patient identifiable data in 2015/16. The CCG uses the IG Toolkit Incident Reporting Tool to report IG Serious Incidents to the Health and Social Care Information Centre (HSCIC), Department of Health, ICO and other regulators.

The CCG submitted the Information Governance Toolkit to Department of Health in March 2016 and achieved Level 2 compliance.

Review of Economy, Efficiency & Effectiveness of the Use of Resources

The majority of expenditure of the CCG is managed through contracts with providers, based on NHS Standard Contract Terms. These contracts are drafted to ensure that value-for-money is at the core of service delivery to the patients of the area. During the year the Governing Body has worked hard to improve patient pathways for the delivery of care to our population. This work has been based on driving improved care at the same or lower cost.

During the year the CCG delivered QIPP savings of £4.21m. Value-for-money has been reviewed by the Governance and Risk Committee of the CCG which has looked in detail at specific areas of service delivery. In addition, our external auditors have reviewed value-for-money and reported on this within the financial statements. Internal Audit has also carried out work which has allowed the CCG to further improve economy, efficiency and effectiveness.

Review of the Effectiveness of Governance, Risk Management & Internal Control

As Accountable Officer I have responsibility for reviewing the effectiveness of the system of internal control within the Clinical Commissioning Group, including our hosting arrangements.

Capacity to Handle Risk

Risk awareness is the responsibility of all members of the Governing Body and of all staff, particularly the senior team. The Risk Management Policy sets out the responsibilities for managing risk. To ensure that all staff and Governing Body Members are aware of how to manage risk, a workshop is scheduled each year to provide training on the risk register.

My review of the effectiveness of the system of internal control is informed by the work of the internal auditors, who have provided significant assurance that the governance and financial controls are effective. My review is also informed by comments made by the external auditors in their management letter and other reports.

I am also informed by the Governing Body, the Executive Team and Clinical Leads within the CCG who have responsibility for the development and maintenance of risk management and the internal control framework. I have drawn on performance information available to me, which is also reviewed by the Quality and Operational Leadership Team on a monthly basis. I am also informed by the Governance and Risk Committee whose members provide rigorous challenge to the way in which the CCG conducts its business.

During the year, the internal auditors completed 6 audits at Thanet level, with another two still in fieldwork. These audits covered the following areas and each received the described level of audit opinion:

- CCG's Assurance Framework and the Risk Management process – reasonable assurance
- Information Governance Toolkit – reasonable assurance
- Critical financial systems including East Kent Financial Systems and East Kent

Payroll – substantial assurance

- Operation of Key Groups and Committees – Reasonable Assurance
- Performance Reporting to the Governing Body – Reasonable Assurance
- HR processes – limited assurance
- Better Care Fund Governance and Readiness – in fieldwork
- Provider Contract Management: Continuing Healthcare – Reasonable Assurance

Following completion of the planned audit work for the financial year for the Clinical Commissioning Group, the Head of Internal Audit has issued an independent and objective opinion on the adequacy and effectiveness of the Clinical Commissioning Group's system of risk management, governance and internal control.

The overall opinion of the Head of Internal Audit for TIAA Ltd is that: "*I am satisfied that sufficient internal audit work has been undertaken to allow me to draw a reasonable conclusion as to the adequacy and effectiveness of NHS Thanet CCG's internal control processes. In my opinion, NHS Thanet CCG has adequate and effective management, internal control processes to manage the achievement of its objectives."*

The Head of Internal Audit considered the Local Counter Fraud Specialist reports throughout the year and there are no significant issues to take into account in preparing his Opinion.

Data Quality

The CCG has a contract with SECSU to validate the performance data it uses in its performance reports. The CCG's Quality and Performance teams are working together to review the IQPR to develop it into a more effective document. The intention is to:

- Strengthen the quality of the detailed information.
- Achieve better integration of project, finance and medicines management information.
- Achieve integration with new reporting requirements for locality clusters/hubs.
- Provide improved analysis and triangulation of the data.

- Provide better focus to the Membership Body and Governing Body on key issues, with particular emphasis on decisions that may need to be taken.
- Introduce a more concise report for Governing Body.

By reducing the volume of data reported to the Governing Body it will provide opportunities to link Governing Body performance reporting to the delivery of strategic objectives, organisational and operational plans and projects designed to improve patient outcomes. This will enhance current governance systems and provide the Governing Body with more meaningful information with which to direct the business of the CCG as it would be based on quality as well as quantity.

The Project Delivery Dashboards and the (planned) Delivery Report will be used to support the revised process.

Data Security

As I reported above, there have been no data security breaches at Thanet CCG and no reports made to the Information Commissioner's Office during the year.

Business Critical Models

The CCG has in hand a number of key projects which would fall under the heading of "business critical models" in accordance with the McPherson report, including development of strategies and policies (for example, for children and mental health services), projects such as the implementation of the Integrated Care Organisation model and development of the East Kent Strategy which relies on robust modelling of capacity. The CCG has put in place Quality Assurance (QA) arrangements which comply with the McPherson report to monitor these developments to ensure proper control. These include having a Senior Responsible Owner (SRO) who oversees each main project and signs it off; external peer review; use of internal audit to check progress; scrutiny by project boards and by independent members of the Governance and Risk Committee; and gateway reviews where appropriate. The CCG uses checklists such as Equality Impact Assessments and a programme dashboard to monitor progress. The programme SRO is content that the QA process is compliant and appropriate, risks are understood, and the use of the outputs are appropriate.

Discharge of Statutory Functions

The CCG has a number of statutory duties under the NHS Act 2006 as amended – sections 14Z15 (2)(a) and (b) -- which it must discharge. These include

- A requirement to improve services: we have done this through setting the priorities in our strategy, through our commissioning contracts and through monitoring performance against targets (page 23)
- A requirement to reduce inequalities: in our strategy we have prioritised those issues which will improve the health outcomes of the most vulnerable in Thanet (page 10)
- A requirement to involve the public and consult on proposed changes to service delivery: we have done this through our public engagement activities, a report of which is on (page 29).
- A requirement to contribute to the joint Health and Wellbeing Strategy – we have worked with the Kent Health and Wellbeing Board and the local Thanet Health and Wellbeing Board to help achieve this (see page 17) .

As the Accountable Officer, I certify that the CCG has complied with the statutory duties laid down by the NHS Act 2006 (as amended by the Health and Social Care Act 2012).

During establishment, the arrangements put in place by the CCG and explained within the *Corporate Governance Framework* were developed with extensive expert external legal input, to ensure compliance with the all relevant legislation. That legal advice also informed the matters reserved for Membership Body and Governing Body decision and the scheme of delegation.

In light of the Harris Review, the Clinical Commissioning Group has reviewed all of the statutory duties and powers conferred on it by the National Health Service Act 2006 (as amended) and other associated legislation and regulations. As a result, I can confirm that the Clinical Commissioning Group is clear about the legislative requirements associated with each of the statutory functions for which it is responsible, including any restrictions on delegation of those functions.

Responsibility for each duty and power has been clearly allocated to a lead staff member. Leaders of the CCG's teams have confirmed that their structures provide the necessary capability and capacity to undertake all of the Clinical Commissioning Group's statutory duties.

Conclusion

No significant control issues have been identified

Hazel Carpenter
Accounting Officer
25 May 2016

Biographies

NHS Thanet CCG Governing Body

Dr Tony Martin, NHS Thanet CCG Clinical Chair

Dr Tony Martin has been a GP at Bethesda Medical Centre, Cliftonville, Margate for over 25 years. He is responsible for the governing body's development and has a passionate belief in helping Thanet people to improve their health. Tony believes in providing joined-up care, involving a multi-agency approach and feels that medicine is about more than prescribing. For Tony, support with self-care and heath advice is essential. He studied medicine at Leicester University and runs a minor operations clinic locally.

Dr Mark Elliott, GP Member

Mark has been a GP at Minster Surgery, near Ramsgate, since 1999. He is a GP member of Thanet CCG's governing body and elected member and chair of the local GP out-of-hours service. Mark is a GP with special interests in dermatology and minor surgery. He runs a minor surgery clinic and is about to restart a Cryotherapy service. He studied medicine in Liverpool and is a member of the British Medical Association (BMA).

Dr Sabin Kamal GP Member (from Dec 2015)

Dr Kamal been working as GP Partner at Summerhill surgery in Ramsgate since 2012. She qualified as a GP in 2007 after finishing GP training in Kent. She is a member of the Royal

College of General Practitioners, British Medical Association and a clinical supervisor for FY2 at Kent Sussex and Surrey Deanery. She is an LMC representative for the Thanet area and since becoming a partner at the surgery three years ago, she has tried to get actively involved in the CCG at a locality level, attending and contributing to meetings, using guidance and best available evidence to shape our service.

Sabin has a strong belief in patients being at the centre of the decision-making process and the strength of integrated care, involving secondary care, the community and voluntary sector and other organisations.

Dr Adem Akyol GP member

Dr Akyol has been a GP at Newington Road Surgery, Ramsgate, since 2005 and is a member of the CCG's governing body. He has a special interest in urgent care, minor surgery, out-of-hours service and ultrasound. Adem studied at Germany's University of Dusseldorf and started practicing in 1994 in Bangor, Wales. During his career he has worked in Germany, The Netherlands, Denmark, Norway, Ghana and Australia. Adem is a member of the British Medical Association and is married with two children. He moved to Kent in 2004.

Hazel Carpenter, Accountable Officer

Hazel is NHS Thanet CCG's Accountable Officer, and also the Accountable Officer for NHS South Kent Coast CCG. She has worked in NHS commissioning organisations across Surrey and Kent since 2002 and has led the development of commissioning organisations, working as Director of Workforce and Organisation Development within NHS Eastern and Coastal Kent Primary Care Trust. In 2011, she was appointed Director of Commissioning Development for NHS Kent and Medway Primary Care Trust. Hazel has supported clinical commissioning development both working with the GP Deans office and through various clinical leadership programmes.

She studied at Leicester University, Kingston University and the University of Manchester. She has been a GP supervisor for the Kent Surrey and Sussex Deanery and is a member of the Chartered Institute of Personnel and Development.

Dr Tariq Rahman, GP member (until Nov 2015)

Dr Rahman has been a GP at Cecil Square Surgery, Margate, since 1990. Tariq is joint lead for urgent and long-term care for the CCG and is also responsible for outreach clinic negotiations with East Kent Hospitals University NHS Foundation Trust (EKHUFT). He studied in Dhaka, Bangladesh, and started practicing as a GP in 1989. Tariq moved to Kent in 1983.

Dr John Neden, GP member

Dr John Neden has been a GP at Eastcliff Practice, Ramsgate, for 25 years and is the CCG's clinical lead for long-term conditions and planned care. John is interested in primary care, with a particular interest in care for patients with advanced disease.

John studied medicine at Cambridge University and King's College, London, and qualified as a GP in 1984. During his career he has worked for Pilgrims Hospices and worked as a Macmillan GP facilitator, a GP with a special interest in chronic pain management and a GP trainer.

Jonathan Bates, Chief Finance Officer

Jonathan is Chief Finance Officer for NHS Thanet CCG and NHS South Kent Coast.
He is a chartered accountant who started his career in the City, auditing large firms and City institutions. After a spell working freelance for the Audit Commission he joined the London Borough of Bromley with responsibility for the schools and colleges finances.
Jonathan joined the NHS in 1995 as Deputy Director of Finance at Maidstone Hospital, and in 2002 he became Director of Finance for Ashford PCT. After a short period as Director of Finance for Swale PCT he joined Medway PCT as Director of Finance and Assurance. In 2012 he was appointed to the Kent and Medway PCT Cluster Board.
Jonathan is the author of three books on public sector finance and management.

Clive Hart, Lay member with responsibility for patient and public engagement

During more than a decade as a local elected representative Clive went on to become both leader of the opposition and eventually the leader at Thanet District Council, each for periods of two-and-a-half years.
He is a firm believer in lifelong learning and in addition to his City and Guilds electrical craft qualifications, Clive also qualified as a Health and Safety Adviser with NEBOSH while working in the electricity supply industry. He later studied and attained distinction at degree level through a course in Voluntary Studies with the CAB, a BTEC Management Studies qualification whilst working at Thanet College and went on to successfully graduate from the Improvement & Development Agency Leadership Academy while a member at Kent County Council.
Clive stood down from his role as a councillor in 2015 to take on the Lay Member PPE role here at NHS Thanet CCG.

Professor Devaka Fernando, Secondary Care Doctor

Sri Lanka-born consultant endocrinologist Professor Devaka Fernando, 56, is NHS Thanet CCG’s independent member for secondary (hospital) care.

After completing his postgraduate training in endocrinology (hormones) in Manchester he returned to Sri Lanka from 1990 to1998 to help set up a new medical school and became honorary foundation professor of medicine and a fellow of the College of General Practitioners of Sri Lanka.

He has been a consultant on projects run by the World Bank to advise Ministries of Health on long-term conditions and integrated health care in Egypt, the Maldives, India and Sri Lanka and has worked with the World Diabetes Foundation and the Welcome Trust.

David Lewis, Lay member governance and audit chair

David is NHS Thanet CCG’s lay member for governance and is also the audit chair. He is also the CCG’s vice chair.

David has been involved in commissioning for a number of years, as a non-executive director and audit chair at NHS Kent and Medway primary care trust and NHS Surrey primary care trust.

He was previously Finance Director at Kent County Council (KCC) for ten years, and Treasurer of Kent Police Authority, where his achievements included negotiating the financial agreement for the Kings Hill Business Park Development and the Medway Tunnel. He studied economics with law at the University of Sheffield and gained a master’s degree in public finance, specialising in environmental economics, at the University of York.

Born in Gillingham, David moved to Staffordshire aged five and returned to Kent in 1986. He is a youth football referee and spends some of his spare time watching Gillingham play football.

Sharon Gardner-Blatch, Chief Nursing Officer

Sharon has nursed in the NHS for over 25 years within London and the South East of England. She has experience of nursing in hospitals including intensive care and out of hospital care. She is passionate about and committed to supporting the total care of patients in partnership with their families / carers. Over the last ten years, Sharon has been committed to driving up standards to achieve high quality patient care which protects patients from avoidable harm. Since moving into commissioning she has been involved in holding NHS organisations to account for their quality of service delivery, service standards and safeguarding of patients.

Dr Jihad Malasi (from 1 Jan 2016)

Canterbury-born Dr Malasi practises from Dashwood Medical Practice, and started his medical career at Margate's QEQM hospital.

Dr Malasi has a particular interest in mental health, and has extensive experience in the field of psychiatric intensive care.

With a keen interest in martial arts and climbing, Dr Malasi also has a background in emergency sports medicine, and has trained with rugby doctors at Twickenham. Married with three children, Dr Malasi is keen to use his knowledge and skill to benefit the work of the CCG.

He said: “Thanet is an exciting area that’s blessed with wonderful assets such as beautiful coastline and cultural scene. But it’s also an area that has pockets of significant deprivation, and this is reflected in life expectancy gaps, child poverty and above-average rates of preventable disease.

“The CCG is committed to tackling these matters, ensuring that the people of Thanet are empowered to lead lives that are as healthy as possible. It’s a great privilege for me to join the CCG governing body and play an active part in shaping the area’s healthcare.”

Senior Staff Members

Ailsa Ogilvie, Chief Operating Officer

Prior to joining the CCG in March 2014 Ailsa worked within the voluntary sector where she held board level positions in Marketing and Operations for over 25 years. She has a track record of leading change in national organisations such as Scope and Age Concern England and has welcomed the opportunity to join Thanet CCG at this exciting time of transformation.

Sue Martin, Company Secretary

Sue Martin joined the CCG as Head of Governance in January 2014. She has worked in the public and not-for-profit sector throughout her career and her most recent position being with the Care Quality Commission (CQC). Sue is a chartered secretary and has many years’ experience of supporting Boards.

REMUNERATION AND STAFF REPORT

Remuneration Report

The Accountable Officer's view is that Senior Managers are those who are voting members of the Membership Body and Governing Body. Information about their remuneration is set out below. The CCG uses the NHS VSM pay scale for remuneration of board level staff. The Chief Nursing Officer is the only exception and remunerated using NHS Agenda for Change pay scale.

The CCG spent £90,430 on consultancy in 2015-16 (2014/15 £224,540).

Salaries and Allowances (Subject to Audit)

The accountable officer, chief finance officer and chief nursing officer work across both South Kent Coast CCG and Thanet CCG. Their salaries are split between the CCGs on a 50:50 split and both net and gross costs are shown below.

Net Cost to Thanet CCG 2015-16						
Name and Title	**(a) Salary (bands of £5,000)**	**(b) Expense payments (taxable) (band of £100)**	**(c) Performance Pay and Bonus Payments (bands of £5,000)**	**(d) Long term performance pay and bonuses (bands of £5,000)**	**(e) All Pension Related Benefits (bands of £2,500)**	**(f) Total (bands of £5,000)**
	£'000	**£'00**	**£'000**	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	55-60	0-1	0	0	7.5-10	60-65
Jonathan Bates - Chief Finance Officer	50-55	0	0	0	2.5-5	55-60
Sharon Gardner-Blatch - Chief Nursing Officer	40-45	0-1	0	0	10-12.5	50-55
Dr Tony Martin - Clinical Chair	65-70	0	0	0	0	65-70
Professor Devaka Fernando - Secondary Care Doctor	40-45	0	0	0	0	40-45
Dr John Neden - Governing Body Elected GP Member	60-65	0	0	0	15-17.5	80-85
Dr Mark Elliott - Governing Body Elected GP Member	30-35	0-1	0	0	0	30-35

Dr Adem Akyol - Governing Body Elected GP Member	15-20	0	0	0	5-7.5	20-25
Dr Tariq Rahman - Governing Body Elected GP Member (01/04/2015 - 30/11/2015)	5-10	0	0	0	0	5-10
Dr Jihad Malasi - Governing Body Elected GP Member (01/01/2016 - 31/03/2016)	5-10	0	0	0	20-22.5	25-30
Dr Sabin Kamal - Governing Body Elected GP Member (01/12/2015 - 31/03/2016)	5-10	0	0	0	25-27.5	30-35
David Lewis - Lay Member (Governance)	10-15	4-5	0	0	0	10-15
Clive Hart - Lay Member (Patient and Public Engagement)	10-15	0.1	0	0	0	10-15

Gross Cost to Thanet CCG 2015-16						
Name and Title	**(a) Salary (bands of £5,000)**	**(b) Expense payments (taxable) (band of £100)**	**(c) Performance Pay and Bonus Payments (bands of £5,000)**	**(d) Long term performance pay and bonuses (bands of £5,000)**	**(e) All Pension Related Benefits (bands of £2,500)**	**(f) Total (bands of £5,000)**
	£'000	**£'00**	**£'000**	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	110-115	1-2	0	0	15-17.5	125-130
Jonathan Bates - Chief Finance Officer	100-105	0	0	0	7.5-10	115-120
Sharon Gardner-Blatch - Chief Nursing Officer	80-85	0-1	0	0	22.5-25	105-110

Please note that the figures shown in 'All Pension Related Benefits' are an estimate of the increase in pension should it be paid over 20 years of life from retirement if there is no benefit then a zero is shown.

Salaries and Allowances: Comparison With Previous Year 2014/15

Net Cost to Thanet CCG 2014-15					
Name and Title	**Salary (bands of £5,000)**	**Expense payments (taxable) (band of £100)**	**Performance Pay and Bonus Payments (bands of £5,000)**	**All Pension Related Benefits (bands of £2,500)**	**Total (bands of £5,000)**
	£'000	**£'00**	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	45-50	1-2	0	0	40-45
Jonathan Bates - Chief Finance Officer	40-45	0	0	0-2.5	40-45
Sharon Gardner-Blatch - Chief Nursing Officer	30-35	1-2	0	20-22.5	50-55
Dr Tony Martin - Clinical Chair	60-65	0	0	60-62.5	125-130
Professor Devaka Fernando - Secondary Care Doctor	40-45	0-1	0	0	40-45
Dr John Neden - Governing Body Elected GP Member	60-65	0	0	0	60-65
Dr Mark Elliott - Governing Body Elected GP Member	30-35	0	0	0	30-35
Dr Andrew Walton - Governing Body Elected GP Member	35-40	0	0	52.5-55	90-95
Dr Adem Akyol - Governing Body Elected GP Member	15-20	0	0	35-37.5	50-55
Dr Tariq Rahman - Governing Body Elected GP Member	15-20	0	0	0	15-20
David Lewis - Lay Member (Governance)	10-15	0-1	0	0	10-15
Dominic Carter - Lay Member (Patient and Public Engagement)	10-15	0	0	0	10-15

Dr Andrew Walton left the CCG on 31/03/2015

Gross Cost of posts shared with SKC CCG 2014-15					
Name and Title	Salary (bands of £5,000)	Expense payments (taxable) (band of £100)	Performance Pay and Bonus Payments (bands of £5,000)	All Pension Related Benefits (bands of £2,500)	Total (bands of £5,000)
	£'000	£'00	£'000	£'000	£'000
Hazel Carpenter - Accountable Officer	110-115	3-4	0	0	110-115
Jonathan Bates - Chief Finance Officer	100-105	0	0	0-2.5	100-105
Sharon Gardner-Blatch - Chief Nursing Officer	75-80	3-4	0	50-52.5	130-135

Pay Multiples

Reporting bodies are required to disclose the relationship between the remuneration of the highest-paid director/Member in their organisation and the median remuneration of the organisation's workforce.

The banded remuneration of the highest paid director/Member in NHS Thanet CCG in the financial year 2015-16 was £112,500 (2014-15, £112,500). This was 2.44 times (2014-15, 2.15) the median remuneration of the workforce, which was £46,164 (2014-15, £52,235).

In 2015-16, 0 (2014-15, 0) employees received remuneration in excess of the highest-paid director/member. Remuneration ranged from £16,633 to £112,500 (2014-15 £16,633 - £112,500)

Total remuneration includes salary, non-consolidated performance related pay, benefits-in-kind, but not severance payments. It does not include employer pension contributions and the cash equivalent transfer value of pensions.

Band of Highest Paid Director's Total Remuneration (£'000)	110-115
Remuneration Median Total	46,164
Remuneration Ratio	2.44

The change from 2.15 to 2.44 is due to the CCG bring some functions, which were previously supplied by South East Commissioning Support Unit, in house. As a result the average staff salary has decreased.

Pension Benefits

Pension Benefits				
Name and Title	(a) Real increase in pension at pension age	(b) Real increase in pension lump sum at pension age	(c) Total accrued pension at pensionage at 31 March 2016	(d) Lump sum at pension age related to accrued pension at 31 March 2016
	(bands of £2,500)	(bands of £2,500)	(bands of £5,000)	(bands of £5,000)
	£'000	£'000	£'000	£'000
Hazel Carpenter - Accountable Officer	0-2.5	0	35-40	100-105
Jonathan Bates - Chief Finance Officer	0-2.5	2.5-5	25-30	80-85
Sharon Gardner-Blatch - Chief Nursing Officer	0-2.5	0-2.5	20-25	55-60
John Neden - GP Member	0-2.5	2.5-5	15-20	45-50
Adem Akyol - GP Member	0-2.5	0-2.5	5-10	15-20
Jihad Malasi - GP Member	0-2.5	2.5-5	0-5	0-5
Sabin Kamal	0-2.5	2.5-5	0-5	0-5

	(e) Cash Equivalent Transfer Value at 1 April 2015 with Inflation added	(f) Real Increase in Cash Equivalent Transfer Value	(g) Cash Equivalent Transfer Value at 31 March 2016	(h) Employer's contribution to partnership pension
	£'000	£'000	£'000	£'000
Hazel Carpenter - Accountable Officer	550	19	569	N/A
Jonathan Bates - Chief Finance Officer	550	25	575	N/A
Sharon Gardner-Blatch - Chief Nursing Officer	308	21	329	N/A
John Neden - GP Member	298	25	323	N/A
Adem Akyol - GP Member	103	5	108	N/A

Jihad Malasi - GP Member	0	13	13	N/A
Sabin Kamal	0	18	18	N/A

Certain Members do not receive pensionable remuneration therefore there will be no entries in respect of pensions for those Members.

Greenbury information for Dr Malasi and Dr Jihad was not received so their pension benefits have been estimated based on other members' benefits.

Dr Tony Martin left the pension scheme on 30/01/2015.

Dr Andrew Walton left the governing body 31/03/2015.

On 16 March 2016, the Chancellor of the Exchequer announced a change in the Superannuation Contributions Adjusted for Past Experience (SCAPE) discount rate from 3.0% to 2.8%. This rate affects the calculation of CETV figures in this report.

Due to the lead time required to perform calculations and prepare annual reports, the CETV figures quoted in this report for members of the NHS Pension scheme are based on the previous discount rate and have not been recalculated.

Pension Benefits: Comparison With Previous Year 2014/15

Name and Title	(a) Real increase in pension at age 60	(b) Real increase in pension lump sum at age 60	(c) Total accrued pension at age 60 at 31 March 2015	(d) Lump sum at age 60 related to accrued pension at 31 March 2015
	(bands of £2,500)	(bands of £2,500)	(bands of £5,000)	(bands of £5,000)
	£'000	£'000	£'000	£'000
Hazel Carpenter - Accountable Officer	0-2.5	0-2.5	30-35	100-105
Jonathan Bates - Chief Finance Officer[1]	0-2.5	0-2.5	25-30	75-80
Sharon Gardner-Blatch - Chief Nursing Officer	2.5-5	7.5-10	15-20	55-60
Tony Martin - Clinical Chair	2.5-5	7.5-10	5-10	20-25

Andrew Walton - GP Member	2.5-5	7.5-10	5-10	25-30
Adem Akyol - GP Member	0-2.5	5-7.5	5-10	15-20
John Neden - GP Member	0-2.5	0-2.5	10-15	40-45

	(e) Cash Equivalent Transfer Value at 1 April 2014 with Inflation added	(f) Real Increase in Cash Equivalent Transfer Value	(g) Cash Equivalent Transfer Value at 31 March 2015 with Inflation added	(h) Employer's contribution to partnership pension
Hazel Carpenter - Accountable Officer	521	23	544	N/A
Jonathan Bates - Chief Finance Officer[1]	515	28	543	N/A
Sharon Gardner-Blatch - Chief Nursing Officer	254	50	305	N/A
Tony Martin - Clinical Chair	102	67	169	N/A
Andrew Walton - GP Member	133	50	184	N/A
Adem Akyol - GP Member	72	30	102	N/A
John Neden - GP Member	285	8	294	N/A

Our staff

The total Thanet CCG Staff employed through ESR was 41 as of the 31 March 2016, and a further 12 employed as Governing Body members and/or Clinical Leads. The FTE is 38.8.

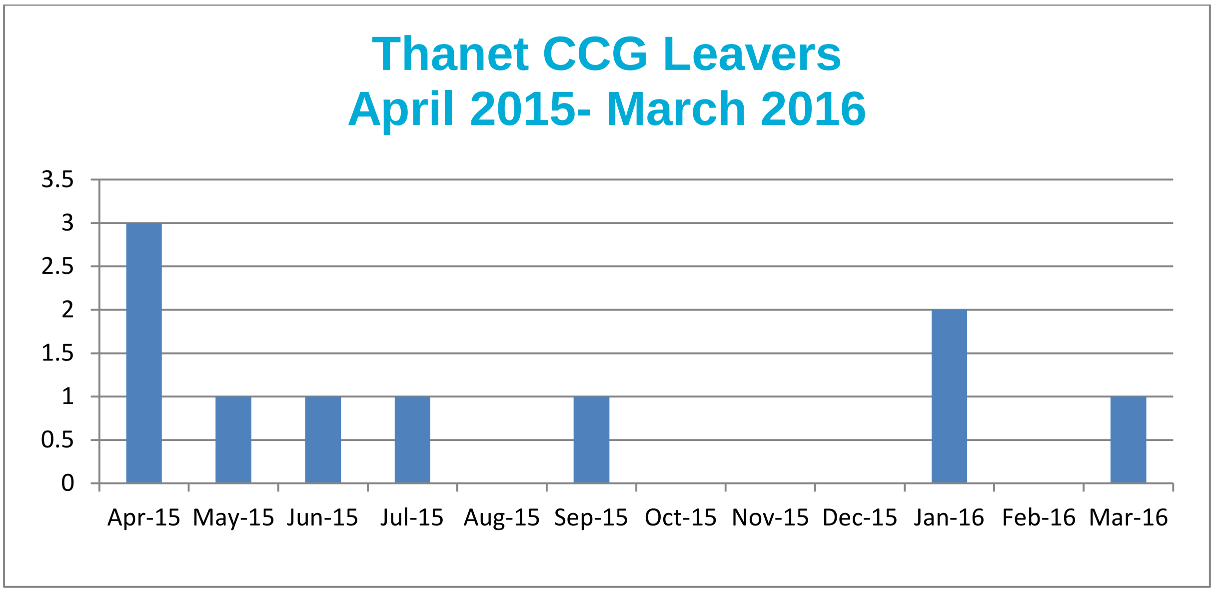
Leavers April 2015 – 2016

A number of members of staff left the CCG during this period for the following reasons:

- 8 Voluntary resignation – (not known/promotion/health/work life balance/other

- 1 Retirement
- 1 End of fixed term contract

Calculating an average of 41 members of staff (excluding GPs) over the period, staff turnover is 24.4%. The national UK average is around 15% with an expected rise of 3% over the next 2 years due to an improving economy.

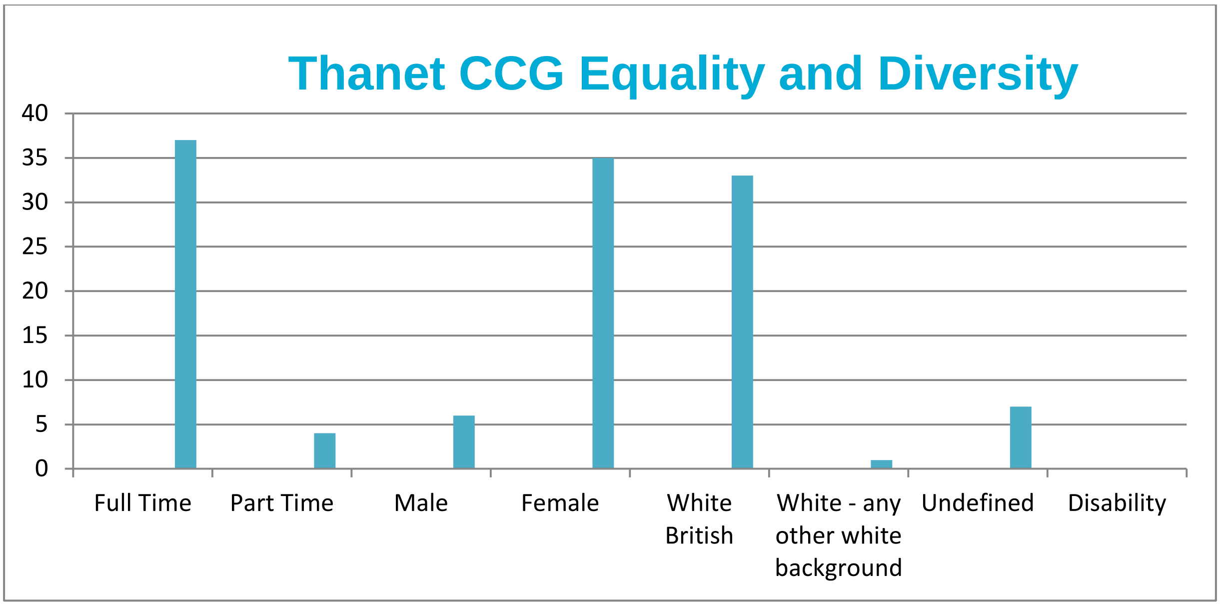


Cultural Diversity

The graph below gives a screen shot of the CCG's diverse workforce and shows that of the staff employed by Thanet CCG, 14.6% are male and 85.3% female.
The number of staff currently working part time has decreased from last year to 9.75%.

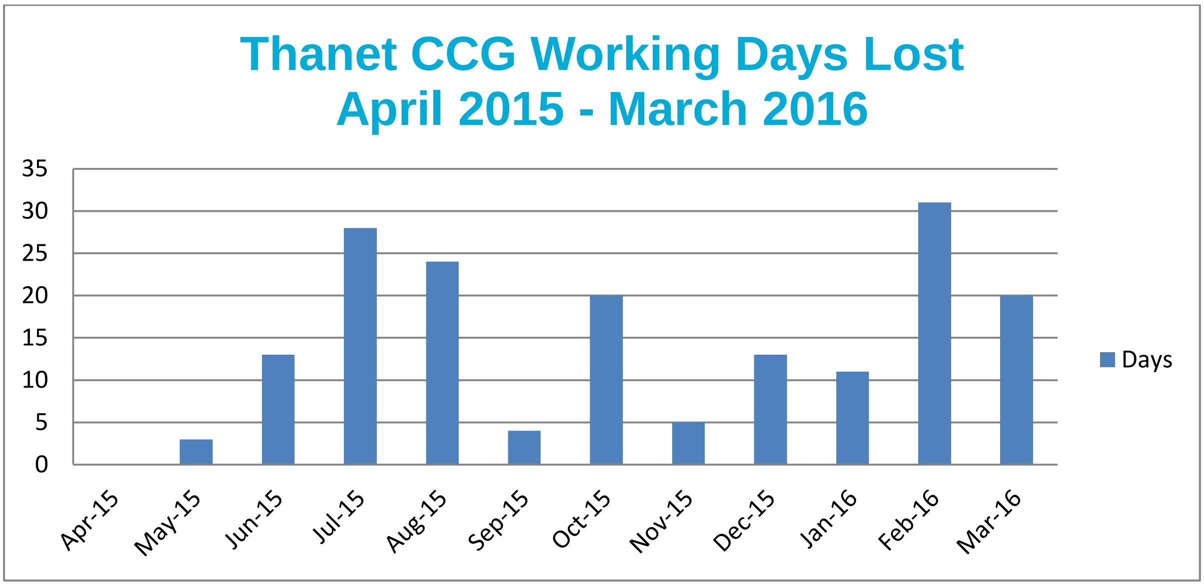
In terms of ethnicity, 80.49% of staff have declared themselves as white British however, a high number of ethnicities are recorded as undefined (17.07%). This is due to the information not being fully completed on starter forms.

No employees have a declared disability.



Sickness Absence

Sickness at Thanet CCG during the period of April 2015 – March 2016 averages at 14.3 days per month from a total availability of 843 working days per month, giving a 1.73% sickness rate. The national average NHS sickness absence rate fluctuates between 4% -4.5%. CCG's specifically, fluctuated between 2% - 3% over the past two years.



Equality Disclosures

The CCG has a Disability Policy which sets out its intentions to ensure that people with disabilities are given full and fair consideration when they apply for employment and that staff with a disability are supported to ensure they are able to be effective as employees. The CCG is committed to achieving its equality objectives and is reviewing the Equality Diversity Standard 2 to identify areas for improvement

Employee Consultation

- The CCG continues to run a joint staff engagement forum with NHS South Kent Coast CCG. The meetings are held on a monthly basis and are chaired by the Company Secretary for both CCGs. In 2015/16 the staff forum ratified policies including sustainability and all HR policies as well as continuing to develop a staff handbook.
- The staff forum also led the annual staff survey, to keep abreast of staff issues. The questions included whether staff feel appropriately supported by their line managers, the training and development offered to them and how visible and accessible the Governing Body members are to staff on a daily basis. The results will be collated and fed back at the staff development days.
- A weekly team meeting is held every Friday morning which gives the Executive Team the opportunity to brief staff on any important matters concerning the business and operations and to recap the previous week's main issues.
- In addition the staff are invited to development days to learn more about each other and how to get the best out of colleagues. How these staff development days are facilitated also formed part of the staff survey as the CCG aims to ensure staff get the most out of them that they can.
- An electronic bulletin is sent to all CCG staff on a weekly basis. This provides a way for the CCG to communicate with the membership on any internal or external issues of relevance to the staff and CCG.

Exit Packages and Severance Payments

There were no exit packages or severance payments made by the CCG in 2015/16.

Off Payroll Engagements

There were no off payroll engagement of staff for more than £220 per day and lasting more than 6 months during 2015/16.

Performance Related Pay

The CCG has no performance related pay policy in operation.

Payments for Loss of Office

There were no payments made for loss of office in 2015/16.

Payments to Past Senior Managers

No payments have been made

INDEPENDENT AUDITOR'S REPORT TO THE MEMBERS OF

NHS THANET CLINICAL COMMISSIONING GROUP

INDEPENDENT AUDITOR'S REPORT TO THE MEMBERS OF THE GOVERNING BODY OF NHS THANET CLINICAL COMMISSIONING GROUP

We have audited the financial statements of NHS Thanet Clinical Commissioning Group (CCG) for the year ended 31 March 2016 under the Local Audit and Accountability Act 2014 (the "Act"). The financial statements comprise the Statement of Comprehensive Net Expenditure, the Statement of Financial Position, the Statement of Changes in Taxpayers' Equity, the Statement of Cash Flows and the related notes. The financial reporting framework that has been applied in their preparation is applicable law and International Financial Reporting Standards (IFRSs) as adopted by the European Union, and as interpreted and adapted by the 2015/16 Government Financial Reporting Manual (the 2015/16 FReM) as contained in the Department of Health Group Manual for Accounts 2015/16 (the 2015/16 MfA) and the Accounts Direction issued by the NHS Commissioning Board with the approval of the Secretary of State as relevant to the National Health Service in England (the Accounts Direction).

We have also audited the information in the Remuneration and Staff Report that is subject to audit, being:

• the table of salaries and allowances of senior managers and related narrative notes on pages 76 to 79

• the table of pension benefits of senior managers and related narrative notes on pages 80 to 82

• disclosure of payments for loss of office on page 86

• disclosure of payments to past senior managers on page 86

• the table of exit packages and related narrative notes on page 86

• the analysis of staff numbers and related narrative notes on pages 82 to 84; and

• the tables of pay multiples and related narrative notes on page 79 to 80.

This report is made solely to the members of the Governing Body of NHS Thanet Clinical Commissioning Group, as a body, in accordance with Part 5 of the Act and as set out in paragraph 43 of the Statement of Responsibilities of Auditors and Audited Bodies published by Public Sector Audit Appointments Limited. Our audit work has been undertaken so that we might state to the members of the Governing Body of the CCG those matters we are required to state to them in an auditor's report and for no other purpose. To the fullest extent permitted by law, we do not accept or assume responsibility to anyone other than the CCG and the members of the Governing Body of the CCG, as a body, for our audit work, for this report, or for the opinions we have formed.

Respective responsibilities of the Accountable Officer and auditor

As explained more fully in the Statement of Accountable Officer's Responsibilities, the Accountable Officer is responsible for the preparation of the financial statements and for being satisfied that they give a true and fair view and is also responsible for ensuring the regularity of expenditure and income. Our responsibility is to audit and express an opinion on the financial statements in accordance with applicable law and International Standards on Auditing (UK and Ireland). Those standards require us to comply with the Auditing Practices Board's Ethical Standards for Auditors. We are also responsible for giving an opinion on the regularity of expenditure and income in accordance with the Code of Audit Practice prepared by the Comptroller and Auditor General as required by the Act (the "Code of Audit Practice").

As explained in the Annual Governance Statement the Accountable Officer is responsible for the arrangements to secure economy, efficiency and effectiveness in the use of the CCG's resources. We are required under Section 21 (1)(c) of the Act to be satisfied that the CCG has made proper arrangements for securing economy, efficiency and effectiveness in its use of resources and to report our opinion as required by Section 21(4)(b) of the Act.

We are not required to consider, nor have we considered, whether all aspects of the CCG's arrangements for securing economy, efficiency and effectiveness in its use of resources are operating effectively.

Scope of the audit of the financial statements

An audit involves obtaining evidence about the amounts and disclosures in the financial statements sufficient to give reasonable assurance that the financial statements are free from material misstatement, whether caused by fraud or error. This includes an assessment of: whether the accounting policies are appropriate to the CCG's circumstances and have been consistently applied and adequately disclosed; the reasonableness of significant accounting estimates made by the Accountable Officer; and the overall presentation of the financial statements. In addition, we read all the financial and non-financial information in the Annual Report to identify material inconsistencies with the audited financial statements and to identify any information that is apparently materially incorrect based on, or materially inconsistent with, the knowledge acquired by us in the course of performing the audit. If we become aware of any apparent material misstatements or inconsistencies we consider the implications for our report.

In addition, we are required to obtain evidence sufficient to give reasonable assurance that the expenditure and income recorded in the financial statements have been applied to the purposes intended by Parliament and the financial transactions conform to the authorities which govern them.

Scope of the review of arrangements for securing economy, efficiency and effectiveness in the use of resources

We have undertaken our review in accordance with the Code of Audit Practice, having regard to the guidance on the specified criteria, issued by the Comptroller and Auditor General in November 2015, as to whether the CCG had proper arrangements to ensure it took properly informed decisions and deployed resources to achieve planned and sustainable outcomes for taxpayers and local people. The Comptroller and Auditor General determined these criteria as that necessary for us to consider under the Code of Audit Practice in satisfying ourselves whether the CCG put in place proper arrangements for securing economy, efficiency and effectiveness in its use of resources for the year ended 31 March 2016, and to report by exception where we are not satisfied.

We planned our work in accordance with the Code of Audit Practice. Based on our risk assessment, we undertook such work as we considered necessary to form a view on whether, in all significant respects, the CCG had put in place proper arrangements to secure economy, efficiency and effectiveness in its use of resources.

Opinion on financial statements

In our opinion the financial statements:

- give a true and fair view of the financial position of NHS Thanet Clinical Commissioning Group as at 31 March 2016 and of its expenditure and income for the year then ended; and
- have been prepared properly in accordance with IFRSs as adopted by the European Union, as interpreted and adapted by the 2015/16 FReM as contained in the 2015/16 MfA and the Accounts Direction.

Opinion on regularity

In our opinion, in all material respects the expenditure and income recorded in the financial statements have been applied to the purposes intended by Parliament and the financial transactions in the financial statements conform to the authorities which govern them.

Opinion on other matters

In our opinion:

- the parts of the Remuneration and Staff Report to be audited have been properly prepared in accordance with IFRSs as adopted by the European Union, as interpreted and adapted by the 2015/16 FReM as contained in the 2015/16 MfA and the Accounts Direction; and
- the other information published together with the audited financial statements in the annual report and accounts is consistent with the financial statements.

Matters on which we are required to report by exception

We are required to report to you if:

- in our opinion the governance statement does not comply with the guidance issued by the NHS Commissioning Board; or
- we refer a matter to the Secretary of State under section 30 of the Act because we have reason to believe that the CCG, or an officer of the CCG, is about to make, or has made, a decision which involves or would involve the body incurring unlawful expenditure, or is about to take, or has begun to take a course of action which, if followed to its conclusion, would be unlawful and likely to cause a loss or deficiency; or
- we issue a report in the public interest under section 24 of the Act; or
- we make a written recommendation to the CCG under section 24 of the Act; or
- we are not satisfied that the CCG has made proper arrangements for securing economy, efficiency and effectiveness in its use of its resources for the year ended 31 March 2016.

We have nothing to report in these respects.

Certificate

We certify that we have completed the audit of the accounts of NHS Thanet Clinical Commissioning Group in accordance with the requirements of the Act and the Code of Audit Practice.

Elizabeth Olive

for and on behalf of Grant Thornton UK LLP, Appointed Auditor

Grant Thornton UK LLP
Grant Thornton House
Melton Street
London
NW1 2EP

25 May 2016

THANET CLINICAL COMMISSIONING GROUP

ANNUAL ACCOUNTS

2015/16

NHS Thanet Clinical Commissioning Group - Annual Accounts 2015-16

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The Primary Statements:

Notes to the Accounts

Statement of Comprehensive Net Expenditure for the year ended 31-March-2016

	Note	2015-16 £000	2014-15 £000
Total Income and Expenditure			
Employee benefits	4.1.1	1,611	1,427
Operating Expenses	5	202,908	195,779
Other operating revenue	2	(458)	(585)
Net operating expenditure before interest		**204,061**	**196,621**
Other (gains)/losses		0	0
Finance costs		0	0
Net operating expenditure for the financial year		**204,061**	**196,621**
Net (gain)/loss on transfers by absorption		0	0
Total Net Expenditure for the year		**204,061**	**196,621**
Of which:			
Administration Income and Expenditure			
Employee benefits	4.1.1	1,327	1,276
Operating Expenses	5	1,817	2,279
Other operating revenue	2	(30)	(31)
Net administration costs before interest		**3,114**	**3,524**
Programme Income and Expenditure			
Employee benefits	4.1.1	284	151
Operating Expenses	5	201,091	193,500
Other operating revenue	2	(428)	(554)
Net programme expenditure before interest		**200,946**	**193,097**

Other Comprehensive Net Expenditure	**2015-16 £000**	2014-15 £000
Total comprehensive net expenditure for the year	**204,061**	**196,621**

The notes on pages 1 to 31 form part of this statement

Statement of Financial Position as at 31-March-2016

	Note	2015-16 £000	2014-15 £000
Non-current assets:			
Property, plant and equipment	8	118	15
Total non-current assets		118	15
Current assets:			
Trade and other receivables	9	2,348	1,441
Other current assets		0	0
Cash and cash equivalents	10	45	71
Total current assets		**2,393**	**1,512**
Total current assets		**2,393**	**1,512**
Total assets		**2,511**	**1,527**
Current liabilities			
Trade and other payables	11	(14,543)	(14,060)
Provisions	12	(65)	(262)
Total current liabilities		**(14,608)**	**(14,322)**
Non-Current Assets plus/less Net Current Assets/Liabilities		**(12,097)**	**(12,795)**
Non-current liabilities			
Trade and other payables		0	0
Provisions		0	0
Total non-current liabilities		**0**	0
Assets less Liabilities		**(12,097)**	**(12,795)**
Financed by Taxpayers' Equity			
General fund		(12,097)	(12,795)
Total taxpayers' equity:		**(12,097)**	**(12,795)**

The notes on pages 1 to 31 form part of this statement

The financial statements on pages 1 to 31 were approved by the Governance and Risk Committee on 23 May 2016 and signed on its behalf by Hazel Carpenter, Accountable Officer

Chief Accountable Officer
Hazel Carpenter

Statement of Changes In Taxpayers Equity for the year ended 31-March-2016

	General fund £000	Total reserves £000
Changes in taxpayers' equity for 2015-16		
Balance at 1 April 2015	(12,795)	(12,795)
Adjusted NHS Clinical Commissioning Group balance at 1 April 2015	**(12,795)**	**(12,795)**
Changes in NHS Clinical Commissioning Group taxpayers' equity for 2015-16		
Net operating expenditure for the financial year	(204,061)	(204,061)
Net Recognised NHS Clinical Commissioning Group Expenditure for the Financial Year	**(204,061)**	**(204,061)**
Net funding	204,758	204,758
Balance at 31 March 2016	**(12,097)**	**(12,097)**

	General fund £000	Total reserves £000
Changes in taxpayers' equity for 2014-15		
Balance at 1 April 2014	(15,213)	**(15,213)**
Adjusted NHS Clinical Commissioning Group balance at 1 April 2014	**(15,213)**	**(15,213)**
Changes in NHS Commissioning Board taxpayers' equity for 2014-15		
Net operating costs for the financial year	(196,621)	(196,621)
Net Recognised NHS Commissioning Board Expenditure for the Financial Year	**(196,621)**	**(196,621)**
Net funding	199,039	199,039
Balance at 31 March 2015	**(12,795)**	**(12,795)**

The notes on pages 1 to 31 form part of this statement

Statement of Cash Flows for the year ended 31-March-2016

	Note	2015-16 £000	2014-15 £000
Cash Flows from Operating Activities			
Net operating expenditure for the financial year		(204,061)	(196,621)
Depreciation and amortisation	8	5	5
(Increase)/decrease in trade & other receivables	9	(906)	300
Increase/(decrease) in trade & other payables	11	484	(2,929)
Provisions utilised	12	(83)	0
Increase/(decrease) in provisions	12	(115)	262
Net Cash Inflow (Outflow) from Operating Activities		**(204,676)**	**(198,983)**
Cash Flows from Investing Activities			
(Payments) for property, plant and equipment	8	(108)	0
Net Cash Inflow (Outflow) from Investing Activities		**(108)**	0
Net Cash Inflow (Outflow) before Financing		**(204,784)**	**(198,983)**
Cash Flows from Financing Activities			
Grant in Aid Funding Received		204,758	199,039
Net Cash Inflow (Outflow) from Financing Activities		**204,758**	**199,039**
Net Increase (Decrease) in Cash & Cash Equivalents	10	**(26)**	**56**
Cash & Cash Equivalents at the Beginning of the Financial Year		**71**	15
Cash & Cash Equivalents (including bank overdrafts) at the End of the Financial Year		**45**	**71**

The notes on pages 1 to 31 form part of this statement

Notes to the financial statements

1.0 Accounting Policies

NHS England has directed that the financial statements of clinical commissioning groups shall meet the accounting requirements of the *Manual for Accounts* issued by the Department of Health. Consequently, the following financial statements have been prepared in accordance with the *Manual for Accounts 2015-16* issued by the Department of Health. The accounting policies contained in the *Manual for Accounts* follow International Financial Reporting Standards to the extent that they are meaningful and appropriate to clinical commissioning groups, as determined by HM Treasury, which is advised by the Financial Reporting Advisory Board. Where the *Manual for Accounts* permits a choice of accounting policy, the accounting policy which is judged to be most appropriate to the particular circumstances of the clinical commissioning group for the purpose of giving a true and fair view has been selected. The particular policies adopted by the clinical commissioning group are described below. They have been applied consistently in dealing with items considered material in relation to the accounts.

1.1 Going Concern

These accounts have been prepared on the going concern basis.

The CCG operated In 2015/16 and has agreed a budget plan for 2016/17 within its annual statutory expenditure limit. The CCG has reviewed affordability of services going forward and is satisfied that statutory financial balance is achieveable.

Public sector bodies are assumed to be going concerns where the continuation of the provision of a service in the future is anticipated, as evidenced by inclusion of financial provision for that service in published documents.

Where a clinical commissioning group ceases to exist, it considers whether or not its services will continue to be provided (using the same assets, by another public sector entity) in determining whether to use the concept of going concern for the final set of Financial Statements. If services will continue to be provided the financial statements are prepared on the going concern basis.

1.2 Accounting Convention

These accounts have been prepared under the historical cost convention modified to account for the revaluation of property, plant and equipment, intangible assets, inventories and certain financial assets and financial liabilities.

1.3 Acquisitions & Discontinued Operations

Activities are considered to be 'acquired' only if they are taken on from outside the public sector. Activities are considered to be 'discontinued' only if they cease entirely. They are not considered to be 'discontinued' if they transfer from one public sector body to another.

1.4 Movement of Assets within the Department of Health Group

Transfers as part of reorganisation fall to be accounted for by use of absorption accounting in line with the Government Financial Reporting Manual, issued by HM Treasury. The Government Financial Reporting Manual does not require retrospective adoption, so prior year transactions (which have been accounted for under merger accounting) have not been restated. Absorption accounting requires that entities account for their transactions in the period in which they took place, with no restatement of performance required when functions transfer within the public sector. Where assets and liabilities transfer, the gain or loss resulting is recognised in the Statement of Comprehensive Net Expenditure, and is disclosed separately from operating costs.

Other transfers of assets and liabilities within the Department of Health Group are accounted for in line with IAS 20 and similarly give rise to income and expenditure entries.

1.5 Pooled Budgets

Where the clinical commissioning group has entered into a pooled budget arrangement under Section 75 of the National Health Service Act 2006 the clinical commissioning group accounts for its share of the assets, liabilities, income and expenditure arising from the activities of the pooled budget, identified in accordance with the pooled budget agreement.
If the clinical commissioning group is in a “jointly controlled operation”, the clinical commissioning group recognises:

* The assets the clinical commissioning group controls;
* The liabilities the clinical commissioning group incurs;
* The expenses the clinical commissioning group incurs; and
* The clinical commissioning group’s share of the income from the pooled budget activities

If the clinical commissioning group is involved in a “jointly controlled assets” arrangement, in addition to the above, the clinical commissioning group recognises:

* The clinical commissioning group’s share of the jointly controlled assets (classified according to the nature of the assets);
* The clinical commissioning group’s share of any liabilities incurred jointly; and
* The clinical commissioning group’s share of the expenses jointly incurred.

1.6 Critical Accounting Judgements & Key Sources of Estimation Uncertainty

In the application of the clinical commissioning group’s accounting policies, management has made judgements, estimates and assumptions about the carrying amounts of assets and liabilities that are not readily apparent from other sources. The estimates and associated assumptions are based on historical experience and other factors that are considered to be relevant. Actual results may differ from those estimates and the estimates and underlying assumptions are continually reviewed. Revisions to accounting estimates are recognised in the period in which the estimate is revised if the revision affects only that period or in the period of the revision and future periods if the revision affects both current and future periods.

1.6.1 Critical Judgements in Applying Accounting Policies

The following critical judgement has a significant effect on the amounts recognised in the financial statements and has been made in the process of applying the clinical commissioning group’s accounting policies. This judgement is in addition to estimations (see below):

Accruals have been included in the financial statements to the extent that the CCG recognises an obligation as at 31 March 2016 for which it has not been invoiced. Estimates of accruals are undertaken by management based on information available at the end of the financial year , together with past experience.

The CCG has reviewed the terms of the Better Care Fund. A Section 75 agreement is in place and the CCG can expend resources without reference to the other members (Kent County Council) and has full control over its element of the budget. The CCG commissions directly as if the pooled budget does not exist and so is outside the pooled budget arrangement. The expenditure by the CCG on the Better Care Fund in the year from 1st April 2015 to 31 March 2016 (2015/16) is £9,699,000.

1.6.2 Key Sources of Estimation Uncertainty

The following key estimations have been made by management in the process of applying the clinical commissioning group’s accounting policies which have the most significant effect on the amounts recognised in the financial statements:

Some of the clinical commissioning group's contracts are not brought to a formal conclusion until late June or early July each year. The clinical commissioning group made estimates on these contracts using the expertise of the commissioning support unit's contracts department.

GP drugs usage is also not known fully until 2 months after the year end. Estimates based on the Prescription Pricing Authority's annual expenditure phasings are made.

1.7 Revenue

Revenue in respect of services provided is recognised when, and to the extent that, performance occurs, and is measured at the fair value of the consideration receivable.

Where income is received for a specific activity that is to be delivered in the following year, that income is deferred.

1.8 Employee Benefits

1.8.1 Short-term Employee Benefits

Salaries, wages and employment-related payments are recognised in the period in which the service is received from employees, including bonuses earned but not yet taken.

The cost of leave earned but not taken by employees at the end of the period is recognised in the financial statements to the extent that employees are permitted to carry forward leave into the following period.

1.8.2 Retirement Benefit Costs

Past and present employees are covered by the provisions of the NHS Pensions Scheme. The scheme is an unfunded, defined benefit scheme that covers NHS employers, General Practices and other bodies, allowed under the direction of the Secretary of State, in England and Wales. The scheme is not designed to be run in a way that would enable NHS bodies to identify their share of the underlying scheme assets and liabilities. Therefore, the scheme is accounted for as if it were a defined contribution scheme: the cost to the clinical commissioning group of participating in the scheme is taken as equal to the contributions payable to the scheme for the accounting period.

For early retirements other than those due to ill health the additional pension liabilities are not funded by the scheme. The full amount of the liability for the additional costs is charged to expenditure at the time the clinical commissioning group commits itself to the retirement, regardless of the method of payment.

1.9 Other Expenses

Other operating expenses are recognised when, and to the extent that, the goods or services have been received. They are measured at the fair value of the consideration payable.

1.10 Property, Plant & Equipment

1.10.1 Recognition

Property, plant and equipment is capitalised if:

* It is held for use in delivering services or for administrative purposes;
* It is probable that future economic benefits will flow to, or service potential will be supplied to the clinical commissioning group;
* It is expected to be used for more than one financial year;
* The cost of the item can be measured reliably; and,
* The item has a cost of at least £5,000; or,

* Collectively, a number of items have a cost of at least £5,000 and individually have a cost of more than £250, where the assets are functionally interdependent, they had broadly simultaneous purchase dates, are anticipated to have simultaneous disposal dates and are under single managerial control; or,

* Items form part of the initial equipping and setting-up cost of a new building, ward or unit, irrespective of their individual or collective cost.

Where a large asset, for example a building, includes a number of components with significantly different asset lives, the components are treated as separate assets and depreciated over their own useful economic lives.

1.10.2 Valuation

All property, plant and equipment are measured initially at cost, representing the cost directly attributable to acquiring or constructing the asset and bringing it to the location and condition necessary for it to be capable of operating in the manner intended by management. All assets are measured subsequently at their current value at existing use.

Fixtures and equipment are carried at depreciated historic cost as this is not considered to be materially different from current value in existing use.

1.11 Depreciation, Amortisation & Impairments

Depreciation is charged to write off the costs of fixtures, plant and equipment non-current assets, less any residual value, over their estimated useful lives, in a manner that reflects the consumption of economic benefits or service potential of the assets. The estimated useful life of an asset is the period over which the clinical commissioning group expects to obtain economic benefits or service potential from the asset. This is specific to the clinical commissioning group and may be shorter than the physical life of the asset itself. Estimated useful lives and residual values are reviewed each year end, with the effect of any changes recognised on a prospective basis.

At each reporting period end, the clinical commissioning group checks whether there is any indication that any of its non-current assets have suffered an impairment loss. If there is indication of an impairment loss, the recoverable amount of the asset is estimated to determine whether there has been a loss and, if so, its amount. Intangible assets not yet available for use are tested for impairment annually.

1.12 Leases

Leases are classified as finance leases when substantially all the risks and rewards of ownership are transferred to the lessee. All other leases are classified as operating leases.

1.13 The Clinical Commissioning Group as Lessee

Property, plant and equipment held under finance leases are initially recognised, at the inception of the lease, at fair value or, if lower, at the present value of the minimum lease payments, with a matching liability for the lease obligation to the lessor. Lease payments are apportioned between finance charges and reduction of the lease obligation so as to achieve a constant rate on interest on the remaining balance of the liability. Finance charges are recognised in calculating the clinical commissioning group’s surplus/deficit.

Operating lease payments are recognised as an expense on a straight-line basis over the lease term. Lease incentives are recognised initially as a liability and subsequently as a reduction of rentals on a straight-line basis over the lease term.
Contingent rentals are recognised as an expense in the period in which they are incurred.

1.14 Cash & Cash Equivalents

Cash is cash in hand and deposits with any financial institution repayable without penalty on notice of not more than 24 hours. Cash equivalents are investments that mature in 3 months or less from the date of acquisition and that are readily convertible to known amounts of cash with insignificant risk of change in value.

In the Statement of Cash Flows, cash and cash equivalents are shown net of bank overdrafts that are repayable on demand and that form an integral part of the clinical commissioning group's cash management.

1.15 Provisions

Provisions are recognised when the clinical commissioning group has a present legal or constructive obligation as a result of a past event, it is probable that the clinical commissioning group will be required to settle the obligation, and a reliable estimate can be made of the amount of the obligation. The amount recognised as a provision is the best estimate of the expenditure required to settle the obligation at the end of the reporting period, taking into account the risks and uncertainties.

When some or all of the economic benefits required to settle a provision are expected to be recovered from a third party, the receivable is recognised as an asset if it is virtually certain that reimbursements will be received and the amount of the receivable can be measured reliably.

1.16 Clinical Negligence Costs

The NHS Litigation Authority operates a risk pooling scheme under which the clinical commissioning group pays an annual contribution to the NHS Litigation Authority which in return settles all clinical negligence claims. The contribution is charged to expenditure, for 2015/16 the contribution was £4,740 (2014/15 £4,739) . Although the NHS Litigation Authority is administratively responsible for all clinical negligence cases the legal liability remains with the clinical commissioning group. The NHSLA has not carried out any claims on behalf of the CCG in 2015/16.

1.17 Non-Clinical Risk Pooling

The clinical commissioning group participates in the Property Expenses Scheme and the Liabilities to Third Parties Scheme. Both are risk pooling schemes under which the clinical commissioning group pays an annual contribution to the NHS Litigation Authority and, in return, receives assistance with the costs of claims arising. The annual membership contributions, and any excesses payable in respect of particular claims are charged to operating expenses as and when they become due.

1.18 Continuing healthcare risk pooling

In 2014-15 a risk pool scheme was been introduced by NHS England for continuing healthcare claims, for claim periods prior to 31 March 2013. Under the scheme clinical commissioning group contribute annually to a pooled fund, which is used to settle the claims.

1.19 Contingencies

A contingent liability is a possible obligation that arises from past events and whose existence will be confirmed only by the occurrence or non-occurrence of one or more uncertain future events not wholly within the control of the clinical commissioning group, or a present obligation that is not recognised because it is not probable that a payment will be required to settle the obligation or the amount of the obligation cannot be measured sufficiently reliably. A contingent liability is disclosed unless the possibility of a payment is remote.

A contingent asset is a possible asset that arises from past events and whose existence will be confirmed by the occurrence or non-occurrence of one or more uncertain future events not wholly within the control of the clinical commissioning group. A contingent asset is disclosed where an inflow of economic benefits is probable.

Where the time value of money is material, contingencies are disclosed at their present value.

1.20 Financial Assets

Financial assets are recognised when the clinical commissioning group becomes party to the financial instrument contract or, in the case of trade receivables, when the goods or services have been delivered. Financial assets are derecognised when the contractual rights have expired or the asset has been transferred.

Financial assets are classified into the following categories:

* Financial assets at fair value through profit and loss;
* Held to maturity investments;
* Available for sale financial assets; and,
* Loans and receivables.

The classification depends on the nature and purpose of the financial assets and is determined at the time of initial recognition.

1.20.1 Loans & Receivables

Loans and receivables are non-derivative financial assets with fixed or determinable payments which are not quoted in an active market. After initial recognition, they are measured at amortised cost using the effective interest method, less any impairment. Interest is recognised using the effective interest method.
Fair value is determined by reference to quoted market prices where possible, otherwise by valuation techniques.

The effective interest rate is the rate that exactly discounts estimated future cash receipts through the expected life of the financial asset, to the initial fair value of the financial asset.

At the end of the reporting period, the clinical commissioning group assesses whether any financial assets, other than those held at ‘fair value through profit and loss’ are impaired. Financial assets are impaired and impairment losses recognised if there is objective evidence of impairment as a result of one or more events which occurred after the initial recognition of the asset and which has an impact on the estimated future cash flows of the asset.

For financial assets carried at amortised cost, the amount of the impairment loss is measured as the difference between the asset’s carrying amount and the present value of the revised future cash flows discounted at the asset’s original effective interest rate. The loss is recognised in expenditure and the carrying amount of the asset is reduced through a provision for impairment of receivables.

If, in a subsequent period, the amount of the impairment loss decreases and the decrease can be related objectively to an event occurring after the impairment was recognised, the previously recognised impairment loss is reversed through expenditure to the extent that the carrying amount of the receivable at the date of the impairment is reversed does not exceed what the amortised cost would have been had the impairment not been recognised.

1.21 Financial Liabilities

Financial liabilities are recognised on the statement of financial position when the clinical commissioning group becomes party to the contractual provisions of the financial instrument or, in the case of trade payables, when the goods or services have been received. Financial liabilities are de-recognised when the liability has been discharged, that is, the liability has been paid or has expired.

1.21.1 Financial Guarantee Contract Liabilities

Financial guarantee contract liabilities are subsequently measured at the higher of:

* The premium received (or imputed) for entering into the guarantee less cumulative amortisation; and,
* The amount of the obligation under the contract, as determined in accordance with IAS 37: Provisions, Contingent Liabilities and Contingent Assets.

1.21.2 Other Financial Liabilities

After initial recognition, all other financial liabilities are measured at amortised cost using the effective interest method, except for loans from Department of Health, which are carried at historic cost. The effective interest rate is the rate that exactly discounts estimated future cash payments through the life of the asset, to the net carrying amount of the financial liability. Interest is recognised using the effective interest method.

1.22 Value Added Tax

Most of the activities of the clinical commissioning group are outside the scope of VAT and, in general, output tax does not apply and input tax on purchases is not recoverable. Irrecoverable VAT is charged to the relevant expenditure category or included in the capitalised purchase cost of fixed assets. Where output tax is charged or input VAT is recoverable, the amounts are stated net of VAT.

1.23 Accounting Standards That Have Been Issued But Have Not Yet Been Adopted

The Government Financial Reporting Manual does not require the following Standards and Interpretations to be applied in 2015-16, all of which are subject to consultation:

* IFRS 9: Financial Instruments
* IFRS 14: Regulatory Deferral Accounts
* IFRS 15: Revenue for Contract with Customers

The application of the Standards as revised would not have a material impact on the accounts for 2015-16, were they applied in that year.

2. Other Operating Revenue

	2015-16 Total £000	2015-16 Admin £000	2015-16 Programme £000	2014-15 Total £000
Charitable and other contributions to revenue expenditure: non-NHS	15	15	0	5
Non-patient care services to other bodies	10	0	10	0
Other revenue	433	15	418	580
Total other operating revenue	**458**	**30**	**428**	**585**

Other Revenue comprises prescribing rebates

Revenue in this note does not include cash received from NHS England which is drawn down directly into the bank account of the CCG and credited to the general fund

3 Revenue

	2015-16 Total £000	2015-16 Admin £000	2015-16 Programme £000	2014-15 Total £000
From rendering of services	458	30	428	585
Total	**458**	**30**	**428**	**585**

Revenue is totally from the supply of services. The clinical commissioning group receives no revenue from the supply of goods.

4. Employee benefits and staff numbers

4.1.1 Employee benefits 2015-16

	Total			Admin			Programme		
	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000
Employee Benefits									
Salaries and wages	1,290	1,265	25	1,053	1,028	25	237	237	0
Social security costs	122	122	0	105	105	0	17	17	0
Employer Contributions to NHS Pension scheme	186	186	0	156	156	0	30	30	0
Termination benefits	13	13	0	13	13	0	0	0	0
Gross employee benefits expenditure	**1,611**	**1,586**	**25**	**1,327**	**1,302**	**25**	**284**	**284**	**0**
Less recoveries in respect of employee benefits (note 4.1.2)	0	0	0	0	0	0	0	0	0
Total - Net admin employee benefits including capitalised costs	**1,611**	**1,586**	**25**	**1,327**	**1,302**	**25**	**284**	**284**	**0**
Less: Employee costs capitalised	0	0	0	0	0	0	0	0	0
Net employee benefits excluding capitalised costs	**1,611**	**1,586**	**25**	**1,327**	**1,302**	**25**	**284**	**284**	**0**

4.1.1 Employee benefits 2014-15

	Total			Admin			Programme		
	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000
Employee Benefits									
Salaries and wages	1,129	1,108	21	978	957	21	151	151	0
Social security costs	105	105	0	105	105	0	0	0	0
Employer Contributions to NHS Pension scheme	142	142	0	142	142	0	0	0	0
Termination benefits	51	51	0	51	51	0	0	0	0
Gross employee benefits expenditure	**1,427**	**1,406**	**21**	**1,276**	**1,255**	**21**	**151**	**151**	**0**
Less recoveries in respect of employee benefits (note 4.1.2)	0	0	0	0	0	0	0	0	0
Total - Net admin employee benefits including capitalised costs	**1,427**	**1,406**	**21**	**1,276**	**1,255**	**21**	**151**	**151**	**0**
Less: Employee costs capitalised	0	0	0	0	0	0	0	0	0
Net employee benefits excluding capitalised costs	**1,427**	**1,406**	**21**	**1,276**	**1,255**	**21**	**151**	**151**	**0**

The remuneration and staff report included within the annual report provides details of the payments made to more senior employees

4.2 Average number of people employed

	2015-16 Total Number	2015-16 Permanently employed Number	2015-16 Other Number	2014-15 Total Number
Total	**49**	**48**	**1**	**39**
Of the above: Number of whole time equivalent people engaged on capital projects	**0**	**0**	**0**	0

4.3 Staff sickness absence and ill health retirements

	2015-16 Number	2014-15 Number
Total Days Lost	172	104
Total Staff Years	32	28
Average working Days Lost	**5**	**4**

	2015-16	2014-15
	Number	Number
Number of persons retired early on ill health grounds	0	0
	£000	£000
Total additional Pensions liabilities accrued in the year	0	0

Ill health retirement costs are met by the NHS Pension Scheme

4.4 Exit packages agreed in the financial year

	2015-16 Compulsory redundancies		2015-16 Other agreed departures		2015-16 Total	
	Number	£	Number	£	Number	£
Less than £10,000	0	0	0	0	0	0
£10,001 to £25,000	0	0	0	0	0	0
£25,001 to £50,000	0	0	0	0	0	0
£50,001 to £100,000	0	0	0	0	0	0
£100,001 to £150,000	0	0	0	0	0	0
£150,001 to £200,000	0	0	0	0	0	0
Over £200,001	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**

	2014-15 Compulsory redundancies		2014-15 Other agreed departures		2014-15 Total	
	Number	£	Number	£	Number	£
Less than £10,000	0	0	0	0	0	0
£10,001 to £25,000	0	0	0	0	0	0
£25,001 to £50,000	0	0	0	0	0	0
£50,001 to £100,000	1	54,913	0	0	1	54,913
£100,001 to £150,000	0	0	0	0	0	0
£150,001 to £200,000	0	0	0	0	0	0
Over £200,001	0	0	0	0	0	0
Total	**1**	**54,913**	**0**	**0**	**1**	**54,913**

4.5 Pension costs

Past and present employees are covered by the provisions of the NHS Pension Scheme. Details of the benefits payable under these provisions can be found on the NHS Pensions website at www.nhsbsa.nhs.uk/Pensions.

bodies, allowed under the direction of the Secretary of State, in England and Wales. The Scheme is not designed to be run in a way that would enable NHS bodies to identify their share of the underlying scheme assets and liabilities.

Therefore, the Scheme is accounted for as if it were a defined contribution scheme: the cost to the clinical commissioning group of participating in the Scheme is taken as equal to the contributions payable to the

The Scheme is subject to a full actuarial valuation every four years (until 2004, every five years) and an accounting valuation every year. An outline of these follows:

4.5.1 Full actuarial (funding) valuation

The purpose of this valuation is to assess the level of liability in respect of the benefits due under the Scheme (taking into account its recent demographic experience), and to recommend the contribution rates to be paid by employers and scheme members. The last such valuation, which determined current contribution rates was undertaken as at 31 March 2012 and covered the period from 1 April 2008 to that date. Details can be found on the pension scheme website at www.nhsbsa.nhs.uk/pensions.

For 2015-16, employers' contributions of £206,466 were payable to the NHS Pensions Scheme (2014-15: £165,918) were payable to the NHS Pension Scheme at the rate of 14.3% of pensionable pay. The scheme's actuary reviews employer contributions, usually every four years and now based on HMT Valuation Directions, following a full scheme valuation. The latest review used data from 31 March 2012 and was published on the Government website on 9 June 2014.

5. Operating expenses

	2015-16 Total £000	2015-16 Admin £000	2015-16 Programme £000	2014-15 Total £000
Gross employee benefits				
Employee benefits excluding governing body members	1,422	1,138	284	1,274
Executive governing body members	189	189	0	153
Total gross employee benefits	**1,611**	**1,327**	**284**	**1,427**
Other costs				
Services from other CCGs and NHS England	1,340	952	388	1,563
Services from foundation trusts	122,745	1	122,744	105,704
Services from other NHS trusts	17,344	0	17,344	32,322
Services from other NHS bodies	0	0	0	0
Purchase of healthcare from non-NHS bodies	28,152	0	28,152	24,552
Chair and Non Executive Members	373	373	0	355
Supplies and services – clinical	2,449	0	2,449	2,132
Supplies and services – general	628	51	578	430
Consultancy services	90	90	0	225
Establishment	409	97	312	551
Transport	6	6	0	4
Premises	465	13	452	524
Impairments and reversals of receivables	0.00	0.00	0	0
Depreciation	5	5	0	5
Amortisation	0	0	0	0
Audit fees	56	56	0	74
Other non statutory audit expenditure				
· Internal audit services	6	6	0	0
· Other services	0	0	0	0
Prescribing costs	26,704	0	26,704	25,380
General ophthalmic services	5	0	5	2
GPMS/APMS and PCTMS	1,248	0	1,248	1,211
Other professional fees excl. audit	210	125	85	176
Clinical negligence	0	0	0	0
Education and training	41	41	0	24
Provisions	- 115	0	- 115	262
CHC Risk Pool contributions	744	0	744	284
Other expenditure	0	0	0	0
Total other costs	**202,906**	**1,816**	**201,090**	**195,779**
Total operating expenses	**204,517**	**3,143**	**201,374**	**197,206**

6.1 Better Payment Practice Code

Measure of compliance	2015-16 Number	2015-16 £000	2014-15 Number	2014-15 £000
Non-NHS Payables				
Total Non-NHS Trade invoices paid in the Year	8,178	44,447	6,691	32,279
Total Non-NHS Trade Invoices paid within target	7,864	43,567	6,511	30,814
Percentage of Non-NHS Trade invoices paid within target	**96.16%**	**98.02%**	**97.31%**	**95.46%**
NHS Payables				
Total NHS Trade Invoices Paid in the Year	2,252	140,028	2,392	142,278
Total NHS Trade Invoices Paid within target	2,214	139,792	2,360	141,828
Percentage of NHS Trade Invoices paid within target	**98.31%**	**99.83%**	**98.66%**	**99.68%**

6.2 The Late Payment of Commercial Debts (Interest) Act 1998

	2015-16 £000	2014-15 £000
Amounts included in finance costs from claims made under this legislation	0	0
Compensation paid to cover debt recovery costs under this legislation	0	0
Total	**0**	**0**

7. Operating Leases

7.1 As lessee

The clinical commissioning group holds two leases with Thanet District Council for the use of two offices within the council builing for a five year term. Both leases cease on 31st March 2021 when the offices will either be vacated or a new lease term will be re-negotiated.

All other property assets are owned by NHS Properrty Services Limited and the charge is based on usage of local premises by providers within our geographical area.

7.1.1 Payments recognised as an Expense

				2015-16				2014-15
	Land £000	Buildings £000	Other £000	Total £000	Land £000	Buildings £000	Other £000	Total £000
Payments recognised as an expense								
Minimum lease payments	0	467	0	**467**	0	501	1	**502**
Contingent rents	0	0	0	**0**	0	0	0	**0**
Sub-lease payments	0	0	0	**0**	0	0	0	**0**
Total	**0**	**467**	**0**	**467**	**0**	**501**	**1**	**502**

7.1.2 Future minimum lease payments

				2015-16				2014-15
	Land £000	Buildings £000	Other £000	Total £000	Land £000	Buildings £000	Other £000	Total £000
Payable:								
No later than one year	0	24	0	**24**	0	0	0	**0**
Between one and five years	0	93	0	**93**	0	0	0	**0**
After five years	0	0	0	**0**	0	0	0	**0**
Total	**0**	**117**	**0**	**117**	**0**	**0**	**0**	**0**

Whilst our arrangements with NHS Property Services Limited fall within the definition of operating leases, rental charge for future years has not yet been agreed . Consequently this note does not include future minimum lease payments for properties owned by NHS Property Services.

8. Property, plant and equipment

2015-16	Buildings excluding dwellings £000	Information technology £000	Furniture & fittings £000	Total £000
Cost or valuation at 01-April-2015	0	0	24	24
Additions purchased	83	15	10	108
Cost/Valuation At 31-March-2016	**83**	**15**	**34**	**132**
Depreciation 01-April-2015	0	0	9	9
Charged during the year	0	0	5	5
Depreciation at 31-March-2016	**0**	**0**	**14**	**14**
Net Book Value at 31-March-2016	**83**	**15**	**20**	**118**
Purchased	83	15	20	118
Total at 31-March-2016	**83**	**15**	**20**	**118**
Asset financing:				
Owned	83	15	20	118
Total at 31-March-2016	**83**	**15**	**20**	**118**

2014-15	Buildings excluding dwellings £000	Information technology £000	Furniture & fittings £000	Total £000
Cost or valuation at 01-April-2014	0	0	24	24
Additions purchased	0	0	0	0
Cost/Valuation At 31-March-2015	**0**	**0**	**24**	**24**
Depreciation 01-April-2014	0	0	5	5
Charged during the year	0	0	4	4
Depreciation at 31-March-2015	**0**	**0**	**9**	**9**
Net Book Value at 31-March-2015	**0**	**0**	**15**	**15**
Purchased	0	0	15	15
Total at 31-March-2015	**0**	**0**	**15**	**15**
Asset financing:				
Owned	0	0	15	15
Total at 31-March-2015	**0**	**0**	**15**	**15**

The addition of £83,000 shown in Buildings excluding dwelling relates to the refurbishment of a new leased property. This lease is for 5 years

8 Property, plant and equipment cont'd

8.1 Economic lives

	Minimum Life (years)	Maximum Life (Years)
Buildings excluding dwellings	5	5
Information technology	3	3
Furniture & fittings	5	5

9. Trade and other receivables

	Current 2015-16 £000	Current 2014-15 £000
NHS receivables: Revenue	890	558
NHS prepayments	364	452
NHS accrued income	80	198
Non-NHS receivables: Revenue	494	35
Non-NHS prepayments	120	83
Non-NHS accrued income	371	81
VAT	30	33
Other receivables	0	2
Total Trade & other receivables	**2,349**	**1,442**
Total current and non current	**2,349**	**1,442**

9.1 Receivables past their due date but not impaired

	2015-16 £000	2014-15 £000
By up to three months	418	46
By three to six months	363	2
By more than six months	3	0
Total	**784**	**48**

10. Cash and cash equivalents

	2015-16 £000	2014-15 £000
Balance at 01-April-2015	71	15
Net change in year	(26)	56
Balance at 31-March-2016	**45**	**71**
Made up of:		
Cash with the Government Banking Service	45	71
Cash in hand	0	(0)
Cash and cash equivalents as in statement of financial position	**45**	**71**
Balance at 31-March-2016	**45**	**71**

No Patients' money is held by the clinical commissioning group.

11. Trade and other payables

	Current 2015-16 £000	Current 2014-15 £000
NHS payables: revenue	2,308	2,648
NHS accruals	1,337	779
Non-NHS payables: revenue	3,561	2,270
Non-NHS accruals	6,634	7,944
Social security costs	24	22
Tax	26	29
Other payables	654	369
Total Trade & Other Payables	**14,544**	**14,061**
Total current and non-current	**14,544**	**14,061**

Other payables include £35,240 (£25,320 2014/15) outstanding pension contributions at 31 March 2016

12. Provisions

	Current 2015-16 £000	Current 2014-15 £000
Continuing care	65	262
Total	**65**	**262**
Total current and non-current	**65**	**262**

	Continuing Care £000s	Total £000s
Balance at 01-April-2015	**262**	**262**
Arising during the year	0	0
Utilised during the year	(83)	(83)
Reversed unused	(115)	(115)
Balance at 31-March-2016	**65**	**65**
Expected timing of cash flows:		
Within one year	65	65
Balance at 31-March-2016	**65**	**65**

This provision relates to Continuing Health Care Retrospective claims outstanding for 2013/14 and 2014/15. This includes claims agreed awaiting settlement as well as pending cases.

13. Contingencies

The Clinical Commissioning Group has no significant contingent liabilities or assets as at 31 March 2016. (31 March 2015 - Nil).

14. Commitments

14.1 Other financial commitments

The NHS Clinical Commissioning Group has entered into contracts with values exceeding £1 million. All contracts are standard NHS contracts which includes break clauses. These clauses are of 12 months or less and are therefore not recognised as financial commitments.

15. Financial instruments

15.1 Financial risk management

Financial reporting standard IFRS 7 requires disclosure of the role that financial instruments have had during the period in creating or changing the risks a body faces in undertaking its activities.

Because the NHS Clinical Commissioning Group is financed through parliamentary funding, it is not exposed to the degree of financial risk faced by business entities. Also, financial instruments play a much more limited role in creating or changing risk than would be typical of listed companies, to which the financial reporting standards mainly apply. The clinical commissioning group has limited powers to borrow or invest surplus funds and financial assets and liabilities are generated by day-to-day operational activities rather than being held to change the risks facing the clinical commissioning group in undertaking its activities.

Treasury management operations are carried out by the finance department, within parameters defined formally within the NHS Clinical Commissioning Group standing financial instructions and policies agreed by the Governing Body. Treasury activity is subject to review by the NHS Clinical Commissioning Group and internal auditors.

15.1.2 Interest rate risk

The Clinical Commissioning Group borrows from government for capital expenditure, subject to affordability as confirmed by NHS England. The borrowings are for 1 to 25 years, in line with the life of the associated assets, and interest is charged at the National Loans Fund rate, fixed for the life of the loan. The clinical commissioning group therefore has low exposure to interest rate fluctuations.

15.1.3 Credit risk

Because the majority of the NHS Clinical Commissioning Group and revenue comes parliamentary funding, NHS Clinical Commissioning Group has low exposure to credit risk. The maximum exposures as at the end of the financial year are in receivables from customers, as disclosed in the trade and other receivables note.

15.1.3 Liquidity risk

NHS Clinical Commissioning Group is required to operate within revenue and capital resource limits, which are financed from resources voted annually by Parliament. The NHS Clinical Commissioning Group draws down cash to cover expenditure, as the need arises. The NHS Clinical Commissioning Group is not, therefore, exposed to significant liquidity risks.

15. Financial instruments cont'd

15.2 Financial assets

	Loans and Receivables 2015-16 £000	Total 2015-16 £000
Receivables:		
· NHS	969	969
· Non-NHS	865	865
Cash at bank and in hand	45	45
Total at 31-March-2016	**1,879**	**1,879**

	Loans and Receivables 2014-15 £000	Total 2014-15 £000
Receivables:		
· NHS	756	756
· Non-NHS	116	116
Cash at bank and in hand	71	71
Other financial assets	2	2
Total at 31-March-2016	**945**	**945**

15.3 Financial liabilities

	Other 2015-16 £000	Total 2015-16 £000
Payables:		
· NHS	3,644	3,644
· Non-NHS	10,849	10,849
Total at 31-March-2016	**14,493**	**14,493**

	Other 2014-15 £000	Total 2014-15 £000
Payables:		
· NHS	3,427	3,427
· Non-NHS	10,582	10,582
Total at 31-March-2016	**14,009**	**14,009**

There is no difference between the carrying value of financial assets and liabilities and their fair value.

As at 31 March 2016 all financial liabilities are due within one year (31 March 2015 - All due within one year)

16. Operating segments

The clinical commissioning group considers it has only one segment: commissioning of healthcare services.

	Gross expenditure £'000	Income £'000	Net expenditure £'000	Total assets £'000	Total liabilities £'000	Net assets £'000
Commissioning of Healthcare	204,519	(458)	**204,061**	2,511	(14,608)	(12,097)
Total	**204,519**	**(458)**	**204,061**	**2,511**	**(14,608)**	**(12,097)**

17. Pooled budgets

The NHS Clinical Commissioning Group's share of the income and expenditure handled by the pooled budget in the financial year were:

	2015-16	2014-15
	£000	£000
Expenditure	(2,083)	(1,843)

In 2003, the former Eastern and Coastal Kent Primary Care Trust entered into a s75 pooled budget arrangement with Kent County Council (KCC) for the provision of an integrated social care centre at Westbrook House, Margate. Following the dissolution of the PCT, the health contribution to this centre is now being provided by the Thanet CCG. Thanet CCG has included within its expenditure £1,993,504 in respect of its contributions to this s75 agreement as a revenue contribution. The other element of the pooled budget relates to the Integrated Community Equipment Service (ICES). This is subject to a s75 agreement with KCC. In 2014-15 the s75 agreement was between KCC and Kent Community Health Foundation Trust. The value of this is £89,300.

The CCG has reviewed the contractual terms of the Better Care Fund. The CCG commissions directly as if the pooled budget does not exist and it is therefore considered to be outside the pooled budget arrangment.

18. Related party transactions

Details of related party transactions with individuals are as follows:

	Payments to Related Party £000	Receipts from Related Party £000	Amounts owed to Related Party £000	Amounts due from Related Party £000
	0	0	0	0

The Department of Health is regarded as a related party. During the year the clinical commissioning group has had a significant number of material transactions (over £1million) with entities for which the Department is regarded as the parent Department. These entities are:

East Kent Hospitals University NHS Foundation Trust
Kent Community Health NHS Foundation Trust
Kent and Medway NHS and Social Care Partnership
South East Coast Ambulance Service NHS Foundation Trust
South East Commissioning Support
Sussex Partnership NHS Foundation Trust
Kings College Hospitals NHS Foundation Trust
Guys & St Thomas NHS Foundation Trust

In addition, the clinical commissioning group has had a number of material transactions with other government departments and other central and local government bodies. Most of these transactions have been with Kent County Council (KCC).

Payments have been made by the CCG to medical practices where members of the governing board are partners. These have not been disclosed as disclosure would infringe the privacy of the other partners in those practices.

19. Events after the end of the reporting period

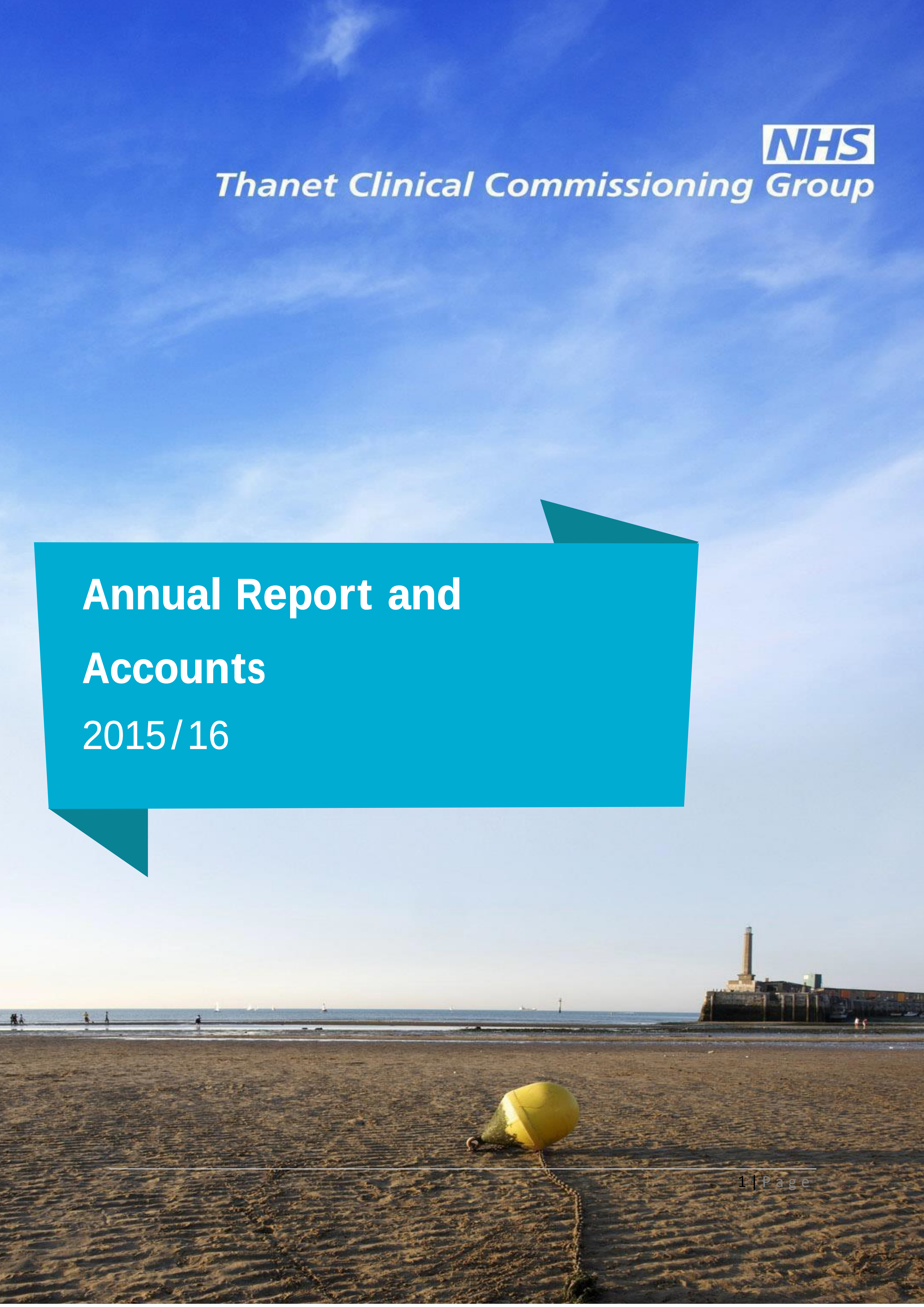
Thanet CCG has no events after the reporting period

20. Financial performance targets

NHS Clinical Commissioning Group have a number of financial duties under the NHS Act 2006 (as amended).

NHS Clinical Commissioning Group performance against those duties was as follows:

	2015-16 Target	2015-16 Performance	2015-16 Variance	2015-16 Target Met	2014-15 Target	2014-15 Performance
Expenditure not to exceed income	206,724	204,627	(2,097)	Y	199,858	197,206
Capital resource use does not exceed the amount specified in Directions	108	108	0	Y	0	0
Revenue resource use does not exceed the amount specified in Directions	206,158	204,061	(2,097)	Y	199,273	196,621
Capital resource use on specified matter(s) does not exceed the amount specified in Directions	108	108	0	Y	n/a	n/a
Revenue resource use on specified matter(s) does not exceed the amount specified in Directions	n/a	n/a	n/a		n/a	n/a
Revenue administration resource use does not exceed the amount specified in Directions	3,213	3,114	(99)	Y	3,524	3,524



NHS
Thanet Clinical Commissioning Group

Annual Report and Accounts

2015/16

Contents

Annual Report for Thanet CCG 2015/16

This is the third Annual Report from NHS Thanet Clinical Commissioning Group (CCG). The Thanet CCG Annual Report and Accounts for 2015/16 covers the period from 1 April 2015 to 31 March 2016.

This Annual Report is published in accordance with the National Health Service Act 2006 (as amended) which requires CCGs to prepare their Annual Report and Accounts in accordance with Directions issued by NHS England. It is in three parts:

- A Performance Report
- An Accountability Report
    - The Members' Report
    - Statement Made by the Accountable Officer
    - Annual Governance Statement
    - Remuneration and Staff Report
- The Annual Accounts

Foreword from the Clinical Chair

Since its inception in 2013, Thanet CCG has always sought to work for the people who live in the area and use its health services.

That central tenet still holds true although we face significant challenges. However, there are real opportunities to transform healthcare in a way that improves health and well-being. Underpinning our philosophy is a belief in the importance of empowering the people of Thanet to make good decisions about their own health: supporting self-care is high on our agenda.

The pressures that Thanet faces are not unique to the area. We have an ageing population, challenging health inequalities, too many urgent care admissions and more people experiencing long-term health conditions. However Thanet also has pockets of deprivation relating to joblessness, deprivation and the placement of vulnerable people where these factors come together in a way more usually found in inner-city areas of the UK.

This means that we have to review our commissioning decisions carefully and allocate resources accordingly. We also can not make the changes we want to make on our own. That is why we are working with our local government partners, other health and social care providers in the area and the voluntary sector to deliver our strategy of integrated care. We want to see organisational barriers which stop people working together effectively removed so that we can deliver better care for patients.

We believe that “local” is usually the best level at which services are delivered. We have focused on developing primary care in four localities in Thanet – Margate, Ramsgate, Broadstairs and Quex (rural Thanet) – so that GPs are at the centre of 7 day coordinated care provision in the community. This work is making progress and we will continue to focus on improving primary care during 2016/17.

We will also continue to emphasise the importance of mental healthcare provision for both children and adults, because in Thanet we have a higher-than-average number of patients with these problems. The links between physical and mental health are strong, and Thanet is making good progress in addressing these needs, particularly with increased referrals for talking therapies. We are responding to the Government's key strategy document, *Five Year Forward View: Mental Health.*

Dr Tony Martin
Clinical Chair on behalf of 17 GP practices of Thanet
May 2016

PERFORMANCE REPORT

Overview

This section of the Annual Report sets out information about the CCG's purpose, what it has done to deliver its purpose and an assessment of how well it has done.

The Responsibilities of the CCG

The Thanet CCG was established in April 2013 under the Health and Social Care Act 2012 as a body corporate. The CCG has responsibilities for commissioning services to meet the healthcare needs for approximately 143,000 people registered with GP practices in Thanet. The services we commission include:

- Community health services (except where part of the public health service)
- Maternity services
- Urgent and emergency care including Accident and Emergency, ambulance and out- of-hours services
- Elective hospital care
- Older people's healthcare services
- Healthcare services for children including those with complex healthcare needs
- Rehabilitation services
- Wheelchair services
- Healthcare services for people with mental health conditions
- Healthcare services for people with learning disabilities
- NHS continuing healthcare.

Although the CCG does not commission pharmaceutical services, we are responsible for the costs of prescriptions written by local GPs. We do not commission dental services or sight tests. Specialist health services, such as secure psychiatric services, continue to be commissioned by NHS England.

At the moment the CCG does not commission GP services, which are commissioned by NHS England. However, the CCG does have a major part to play in improving the quality of primary care and our Membership Development Team, led by several Clinical Leads, work with all the GP practices to help them improve. During 2015/16 NHS England asked all CCGs to re-consider whether they were willing to take on commissioning primary care services, either jointly with NHS England or on their own. While the members of the CCG agree that local commissioning of services works best, we considered the options carefully but decided to continue with the current arrangements for a further 12 months. The Membership will consider this issue again in November 2016.

Meeting the Health Care Needs of Local People

There are significant levels of deprivation in Thanet. It is ranked in the 10% most deprived districts in England and more than a quarter of the children in Thanet are classed as living in poverty.

- ### Population

  Compared to the Kent average, Thanet has a lower percentage of people of working age and a higher proportion of elderly people

  Thanet's population is ageing: currently 22.6% of the Thanet population are aged over 65 and this is predicted to continue to rise significantly over the next 20 years.

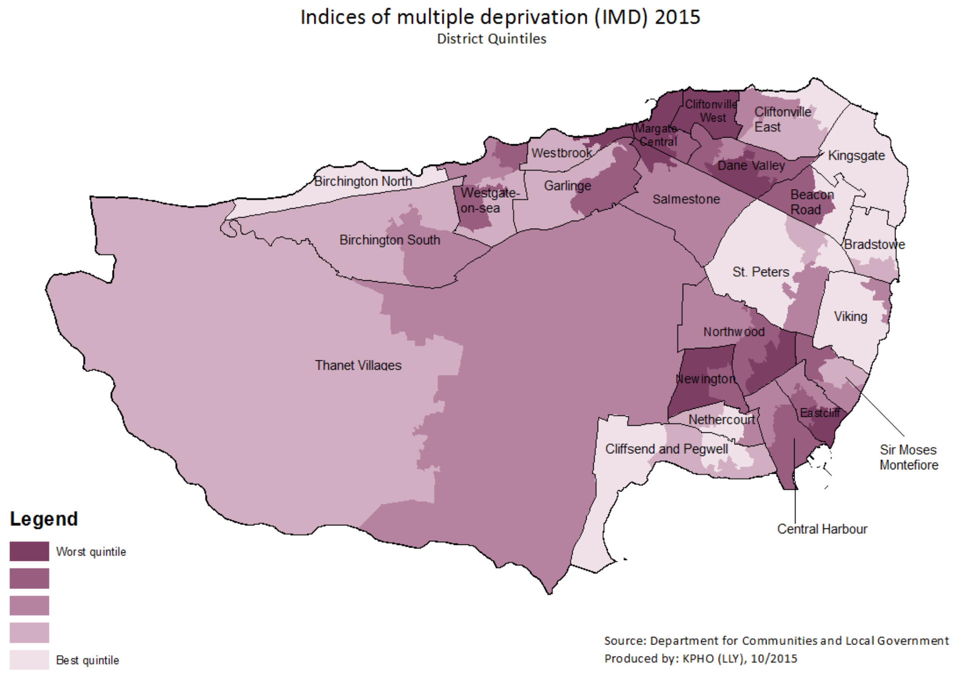
- ### Geography

  Thanet is made up of three coastal towns, Ramsgate, Margate and Broadstairs with a rural hinterland of a number of small villages. The area is dependent on tourism, meaning the coastal towns in particular face the socio-economic disadvantages common to many such areas.

  Levels of unemployment have risen in recent years and remain the highest in Kent, with 2.6% of working people claiming Job Seekers Allowance (twice the Kent average).

  Thanet has significant areas of high deprivation in both Margate and Ramsgate, and comparatively few areas of affluence. Of the 84 lower super output areas (LSOAs) in Thanet, 18 are in the 10% most deprived in the country. One area of Cliftonville in

Margate has been classed as the 4th most deprived of the 32,844 LSOAs in the country.[1]



Vulnerable People

Thanet's seaside location has made it a popular retirement destination leading to a high proportion of older people within the population. The health needs of the older population tend to be more complex and this puts greater pressure on health services locally.

Thanet has a high proportion of people with mental health needs, and also has a very high proportion of looked after children (LAC) and care leavers. The number of LAC is over twice the Kent average and 45% of these originate from outside of Kent (figure 5).

1 https://www.gov.uk/government/organisations/department-for-communities-and-local-government

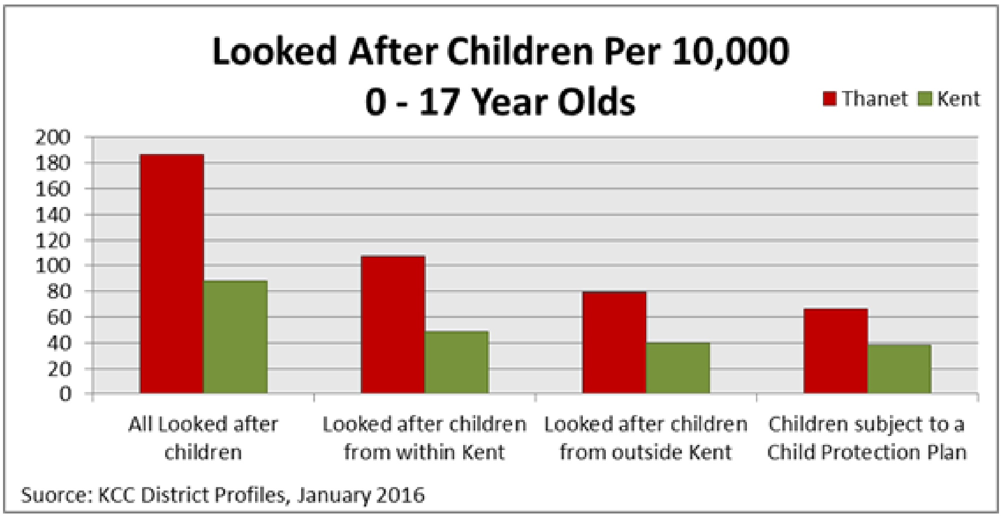


Figure 5

The rate of children in 'poverty' (proportion of children in families living in receipt of out of work benefits or tax credits where their reported income is less than 60% median income) is higher in Thanet at 25.1%, vs 15.6% in KCC area.

- ## Lifestyle

Within Thanet there is a high prevalence of unhealthy behaviours, such as smoking, obesity, binge drinking and unhealthy eating. It is estimated that less than 30% of people in Thanet eat the recommended amount of fruit and vegetables. Thanet has the highest levels of smoking within Kent. One in five people within Thanet are classified as obese. There are also wards where the estimated prevalence of binge drinking is estimated to be more than 20% (for example in Cliftonville West). Therefore it is vital that health services in Thanet support people to develop a healthy lifestyle. Health promotion needs to be relevant and achievable.

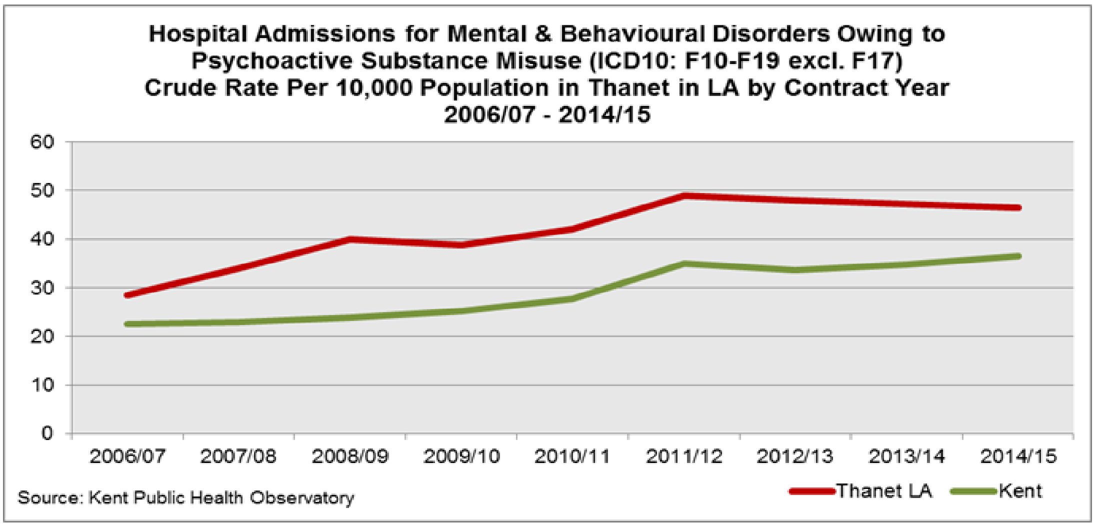
- ## Crime and Substance Misuse

Thanet has a higher crime rate per 1,000 population than any other district in Kent (83.54 for year ending June 2015 vs 61.13 Kent average[2]). The rate of violent crimes (including sexual offences) per 1,000 population is 26.49 vs a Kent average of 17.97.

[2] https://www.thanet.gov.uk/publications/housing/selective-licensing-scheme-2012-2016/the-profile/

Thanet also has the highest rates of substance misuse in Kent with significant amounts of alcohol-related harm and the highest rate of drug offences across the Kent policing area. This places further burdens on the health economy, for example hospital admissions for mental and behavioural disorders owing to psychoactive substance misuse per 10,000 population are significantly higher than the Kent average.

Figure 6.



Health Inequalities in Thanet

Health inequalities in Thanet are a serious concern. The CCG regularly reviews information reported through a variety of sources such as the Atlas of Variation and Commissioning for Value packs as well as other sources such as the Kent Joint Strategic Needs Assessment (JSNA). The following highlights some of the key issues locally.

- ### Life Expectancy

The life expectancy of Thanet residents is the lowest in Kent at 80.19 years. Within Thanet there are significant variances with a gap of 17 years between Margate Central ward (73.6yrs) and Kingsgate ward (90.3yrs).

- ## Mortality and Long Term Conditions

During 2014, 30% of all deaths in Thanet had an underlying cause of cancer. According to 2014/15 Quality Outcomes Framework (QOF), Thanet had a 2.66% prevalence of cancer, compared to 2.47% during the previous year. This was the third highest rate across Kent and Medway. One year survival rates after a cancer diagnosis were last reported at 64.1% (2012-13); this is in the worst quintile nationally. The death rate from cancer in people aged under 75 years is 150 per 100,000 - in the worst quartile nationally.

Thanet has a high mortality rate from coronary heart disease (CHD) but a low diagnosis rate. We spend £1.9 million more on care for patients with circulation problems than some of our demographically similar peers and yet outcomes for patients and the quality of care are not as good. The picture is similar for respiratory problems with more money spent than similar CCGs but with poorer outcomes for those with Chronic Obstructive Pulmonary Disease (COPD). Work has started at our Bethesda practice to improve identification of people with CHD

Obesity in Thanet was 9.9% in 2013/14 in line with the rest of Kent (9.8%). Whilst Thanet is not a particular outlier for obesity or diabetes, the impact of growing obesity and increases in the number of people with diabetes is having the same impact within Thanet that is being seen nationally. When we compare ourselves to demographically similar CCGs, we spend more on care for patients with diabetes but do not achieve the same outcomes for patients.

- ## Mental Health

Thanet has the highest prevalence of people identified with mental health issues when compared to similar CCGs nationally. According to the 2014/15 QOF data, prevalence was at 1.04%, higher than 1.01% for the previous year.

There is a rising demand for Child and Adolescent Mental Health Services and specifically ASC/ADHD diagnosis and treatment services.

Compared to demographically similar CCGs we have not achieved the same level of quality of care for people with mental health conditions.

- ### Children and Maternity

Thanet is within the worst quintile for inpatient costs for under 5 year olds for a number of conditions, including neurological, cancer and gastro-intestinal specialties, but Thanet performs particularly poorly for musculoskeletal specialties, with the second highest costs nationally per 1,000 population.

Thanet has the highest teenage conception rate in Kent at 39 conceptions per 1,000 females aged 15-17. In Cliftonville West the rate is close to one in ten. In addition 20.2% of women in Thanet are recorded as smokers at the time of delivery. This is the highest rate not only in Kent, but across all NHS England South (South East) CCGs.

- ### Frailty

Thanet has a high rate of emergency admissions for people aged 75+ with a length of stay of less than 24 hours. The rate is the highest across similar CCGs to Thanet, and is the fourth highest rate of all CCGs in England.

Thanet has one of the highest rates of undiagnosed dementia in England, currently it is estimated that around 40% of cases are undiagnosed. Thanet also has a high rate of emergency admissions to hospital of people with dementia.

Thanet is also in the lowest quintile for reported health gain from hip replacements and has a high rate of emergency readmissions within 28 days following hip replacements.

What Local People Have Said

Our strategy to enable us to meet our responsibilities takes account of the health needs of the population and has been developed in consultation with local people. We are committed to ensuring patient and the public views are at the heart of shaping our healthcare services. Over the past year we have been listening, engaging and involving patients and the public. These are some of their concerns

- Patients are concerned about the difficulty in obtaining GP appointments
- Patients believe there is a need for a seven day service
- Patients are concerned about a shortage of consultants (e.g. Stroke and A&E consultants)
- Patients are concerned about excessive waiting times
- Patients believe that rehabilitation and after-care needs to be improved as after-care is poor following discharge.
- Patients are concerned about the distance between hospitals
- Patients are concerned about the way funds are allocated for Personal Health Budgets and the costs associated with running the scheme.
- Patients would like more initiatives like "Thanet Big Health Checks" taken into places such as schools, surgeries, supermarkets and pharmacies.

The CCG's Strategy: Transformation and Integration

We have used the information we have about local health challenges, taking account of what local people say, what our members are saying, what the NHS has mandated for us nationally, and what our partners on the Kent Health and Wellbeing Board and the Thanet Health and Wellbeing Board have agreed to develop our strategy.

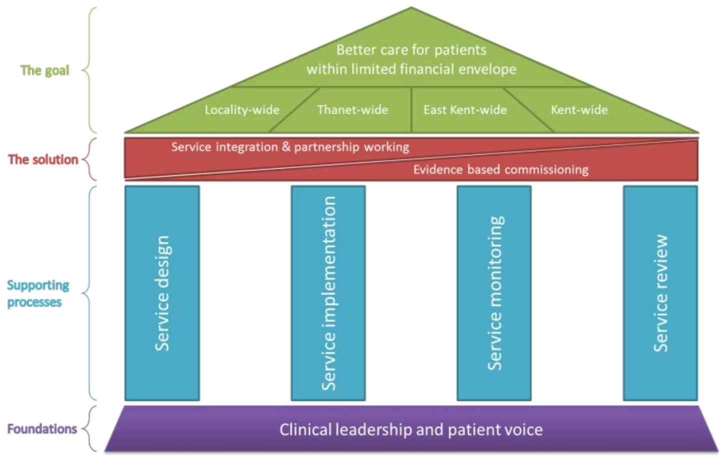
As a CCG, we want to build a local health system that works together, delivers clinically safe and effective services for the public in a timely manner, offers value for money and raises the quality of patient care. A key part of our strategy is to develop and deliver a new model of integrated care that is "wrapped around" individual patients, rather than being provided in a piecemeal way to the preferences of the different organisations providing care. Within Thanet this approach will be delivered via a Multispecialty Community Provider (MCP) operating as an Integrated Accountable Care Organisation (IACO).

Improving care and developing more integrated patient pathways will add value to patient experience, improve outcomes and save money which can be reinvested elsewhere into the care system.

We identified five aims which would enable us to move towards achieving our strategic goals. These were that all patients should receive:

- High quality, equitable, accessible and integrated GP Services
- High quality, integrated out of hospital care covering physical and mental health
- Timely, clinically appropriate and high quality care in hospital
- High quality mental health and wellbeing care in the most appropriate setting
- High quality children's and maternity services

In achieving transformational change we will continue to draw on our patients' views and use robust needs assessment in identifying our priorities. The commissioning and redesign of services will be informed by effective clinical engagement, recognised best practice, and performance data analysis, in a context of an absolute requirement for improving the health and social care outcomes and system sustainability.



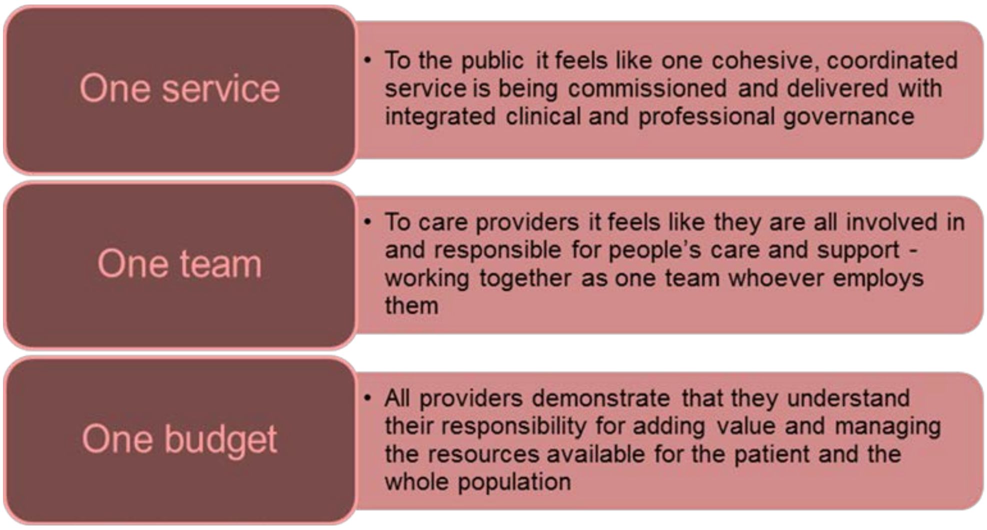
Working in Partnership to Deliver Integration

Thanet CCG and other local NHS and social care partners recognise that the current pattern of health and social care locally cannot continue in its current form. As populations become older and are living longer with more complex conditions, there is a growing demand on health and care services. With the current financial position and the public wanting integrated services to support independence in their own home, it has become essential that care is delivered differently to meet demand and improve quality and outcomes.

Thanet CCG believes that integration of health and social care is the way forward; delivering better care, improving quality and outcomes for citizens as well as efficiencies across the system. Integrated Care is a fundamentally different way to meet health and care needs for a defined population and tailored care to meet individual needs. It means changing the design of services, the people that deliver them and how services are paid for.

Integrated care service models mean that the traditional segmentation of care by provider organisations is no longer appropriate. In the first instance, integrated care means that care services, the care team, and the overall budget for the health and care for a defined community have to be brought together.

The vision for integrated care within Thanet:



Thanet CCG has an outline model for integration which has been designed locally. The Thanet vision for integrated health and social care will be delivered via a MCP operating as an Integrated Accountable Care Organisation (IACO). Ultimately, the aim is to deliver a model for health and care services out of the acute hospital, wrapped around the patient and co-ordinated by their GP, designed and delivered around local patients. The service model will provide strong town based (Margate, Ramsgate, Broadstairs and Quex) integrated health and social care teams – built to enable GP practices to work together within a single infrastructure. This local service model will be supported through a 'hub' based at the local acute hospital. QEQM (the local acute Hospital which currently forms part of EKHUFT) will be redesigned as part of the Hospital Trust's clinical strategy aligned with the Thanet IACO to be a 'community orientated acute site'. QEQM is ideally physically positioned to be only a short distance from most patients. Serving a population of more than 140,000, the services that can be brought into and maintained for the Isle economically are considerable.

More about the IACO can be found in our Operational Plan for 2016/17 at http://www.thanetccg.nhs.uk/home/

We cannot achieve this vision on our own. Delivering this vision involves us working closely with local people and organisations, including Kent County Council, Thanet District Council, providers of health and social care and the voluntary and community sector to prioritise and co design the services that each community needs.

We have worked with our partners as a whole system. Our health partners include the local providers – East Kent Hospitals University Foundation Trust (EKHUFT), Kent Community Health NHS Foundation Trust (KCHFT), NHS Kent and Medway Social Care Partnership Trust (KMPT), South-East Coast Ambulance (SECAMB) and other CCGs in Kent and Medway, particularly those in East Kent.

We also work with Kent County Council and Thanet District Council through the local Health and Wellbeing Board and the Kent Health and Wellbeing Board, to make sure that what we commission can be delivered at the most appropriate level through the NHS and social care working together. A key platform for improving the health economy of Thanet is through the Thanet Health and Wellbeing Board, which is helping us improve mental health, children and maternity services and care for Over 75s. The local Health and Wellbeing Board aims to become an equal partnership of local commissioners working in a single commissioning structure to oversee the local health and wellbeing system. Pooled budgets are an aspiration for the future. At the moment, each commissioning partner retains control of its own budget.

Integration Using The Better Care Fund

Thanet CCG realises the opportunity that joint commissioning and the Better Care Fund (BCF) can provide to meet the health and social care needs of the local population in an integrated and shared way. The BCF is best described as a single pooled budget for health and social care services to work more closely together in local areas. This offers a substantial opportunity to bring resources together to address immediate pressures on services and lay foundations for a much more integrated system of health and care delivered at scale and pace.

Within our plan we have set out a clear vision of how services will look by 2020. We have used the basis of the BCF to support 6 key programmes. These are:

1. Enhanced Primary Care – including self-care
2. Integrated Health and Social Care teams
3. Flexible use of care homes

4. Falls prevention
5. Support for carers
6. Improving end of life care

We will use these areas to help us deliver change within our local health economy, with the patient at the centre of delivery.

We are committed to not only providing seven-day health and social care services but also furthering this to a proactive model of 24/7 community based care. Adult Social Care has shifted working hours to be 8am to 8pm, seven days per week as standard. Further work is taking place within the Adult Social Care Transformation Programme to identify the steps required to achieve extended working hours in all areas of delivery.

East Kent Strategy Board

The four East Kent CCGs and partners have agreed to work together to develop the model of health and social care services for East Kent. The partners aim to achieve the following outcomes:

- A consensus about how to meet the current and future needs of local people, building a model of care which is based in the local community wherever possible and is co-ordinated by the GP around the patient
- Options to deliver the model of care will have clinical credibility and ensure patient safety
- A service model that is supported by the local population and their political representatives
- The model of care that provides equality of access to users
- A model of care which is proactive and sustainable for the future, including providing equality of access to high quality services for local people

Our progress during 2015/16

High quality, equitable, accessible and integrated GP Services

- Progressed integrated working at practice level through the development of four localities within Thanet: Margate, Quex, Ramsgate and Broadstairs.
- Established integrated community nursing teams in the Margate locality, with teams in Quex, Ramsgate and Broadstairs due to come on line over the coming months.

High quality, integrated out of hospital care - physical & mental health

- Increase in the proportion of people with dementia who are diagnosed from 49% to 61.1%
- Age UK service provided support for 375 vulnerable elderly people within the community. An improvement in wellbeing was noted for 96% of patients who were assessed before and after they received the service.
- Introduction of bespoke dementia service delivered by Crossroads Care which provided a range of support including personal care, help with medication and night sits to enable carers to have an uninterrupted night's sleep. During the first three months of the service, eighteen patients with dementia have had their hospital stay made shorter or prevented.
- Agreed improved medicines care arrangements for the Victoria Unit at Westbrook House, ensuring patient safety is maintained.
- Launched new and improved COPD pathway with the introduction of the Patient Passport.
- Developed East Kent carer patient information packs and introduced 'Just in Case' medication boxes as part of palliative care which aims to keep people in their place of choice at the end of their life.

Timely, clinically appropriate and high quality care in hospital

- 3200 GP referrals for trauma and orthopedics reviewed by the new Collaborative

Orthopedic Referral Point (CORP) ensuring appropriate care provided for these patients and reducing pressure on hospital resources.

- Reduction of 3.7% in the number of non-elective admissions for over 75s.
- Implementation of 'Discharge to Assess', to support smooth flow through A&E, avoid hospital admissions and reduce delayed transfers of care.
- 99.8% of diagnostic tests carried out within 6 weeks of referral.
- 81% of life threatening emergencies were responded to by ambulance services within 8 minutes (national target 75%).

High quality mental health & wellbeing care in the most appropriate setting

- 25% of the estimated number of people suffering from depression and anxiety in Thanet accessed psychological therapies (national target is 15%).
- Reduction of 48% in the average numbers of mental health inpatients placed out of area over the second half of the year, enabling patients to be closer to their families and support networks.

High quality children's and maternity services

- Established the new East Kent Children's commissioning team hosted by Thanet CCG. Strategy and work plan developed.
- Submitted transformation plan for children and young people's mental health and successfully achieved funding.
- Implemented transformation schemes:
    - Support for children in schools demonstrating risky behavior particularly relating to self harm;
    - Collaborated with other CCGs on services for unaccompanied asylum seeking children;
    - Increased capacity for eating disorder intervention;
    - Commissioned 3rd sector organisation to support schools regarding emotional wellbeing and resilience;

  - Continued scheme to provide 24hr psychiatric liaison service for children after the ending of winter pressure funding.
- Agreed action for Looked After Children (LAC) placed within Thanet with other public sector partners.
- Agreed local offer for personal health budgets to be in place from April 2016.

There is still much more to do

- Only 86.3% of patients at East Kent Hospitals stay less than four hours in A&E (national target 95%).
- Compliance with the referral to treatment standard was not sustained.
- Unable to meet cancer waiting times standards consistently.
- Under-reporting of activity undertaken by Kent Community Health NHS Foundation Trust.
- A number of CQC inspections reported failings relating to care provided in hospital and out of hospital.
- Closure of two GP practices and some care homes resulting in reduced capacity in the local health economy.
- A significant increase in the number of delayed transfers of care from community and mental health hospitals, particularly relating to patients requiring social care support.

Financial Overview

The CCG has met its statutory duty to achieve financial balance in 2015/16 and has completed its third year of operation achieving its statutory financial targets. However, the CCG used all its contingency funds set aside in order to do this. The cost improvement programmes included within the Quality Innovation, Productivity and Prevention (QIPP) achieved an overall reduction in expenditure of £4.21m. The CCG managed to achieve a 1% surplus (£2.097m), as agreed with NHS England.

Thanet CCG has approved its budget for 2016/17 to enable it to deliver its strategic objectives. The CCG has an annual budget of £210 million to pay for healthcare for the

143,000 people registered with a GP practice within Thanet. That equates to around £1,472 (2015/16 £1,442) per person. More detail about the income and expenditure of the CCG will be found in the annual accounts. The external auditors have confirmed that the CCG remains a going concern.

We commission health services primarily from 3 local providers: East Kent Hospitals University Foundation Trust (EKHUFT), Kent and Medway NHS Partnership Trust (KMPT) and Kent Community Healthcare NHS Foundation Trust (KCHFT). The CCG also commissions other services: for example from South East Coast Ambulance (SECAmb); tertiary providers such as, Guys and St Thomas Hospital and Kings College Hospital; and an out of hours' service from IC24.

Hosting arrangements are in place with:

- Canterbury and Coastal CCG for the Financial Services Team.
- Kent and Medway NHS Partnership Trust for Payroll Services.
- South East Commissioning Support Unit (SECSU) for HR and Contract Support Services.
- Shared Business Services (SBS) for managing the general ledger.
- South Kent Coast CCG for shared staff and mental health commissioning support.
- Thanet CCG hosts the Children's Commissioning Support Team.

In addition, The CCG has entered into collaborative agreements with Kent County Council (KCC) and with other CCGs to share responsibility for the provision of services.

NHS England Assessment

NHS England's assessment of the CCG's performance at the end of March 2016 was overall assessed as "Assured with Support". This was made up of two ratings: "Assured as Good" in relation to Financial Management and Performance but "Limited Assurance: Requires Improvement" because our acute Trust has failed to meet significant constitutional and access standards, particularly Accident and Emergency 4 hour waits, 62 day cancer waits and referral to treatment within 18 weeks.

Performance Analysis

Measuring our performance

The CCG set targets for itself to monitor its performance. In addition, the CCG holds the providers to account for delivery against the Constitutional/Access standards set by Department of Health.

MEASURE	2015/16 PERFORMANCE	TARGET	COMMENT
In Hospital			
% A&E patients seen, treated, admitted or discharged within 4 hours	86.3%	95%	Data is for EKHUFT as a whole, not just Thanet CCG patients. As has been seen across the country EKHUFT has struggled to meet the 4 hour target. A contract performance notice has been in place and remedial action plans are being implemented. Recent developments include Thanet CCG working with staff at QEQM to understand issues at the site and inform improvements within primary and secondary care. This has involved the implementation of organisational change within QEQM which is being monitored monthly at a specific QEQM A&E meeting.
% patients waiting under 18 weeks between referral to treatment	89%	92%	Performance improved to 92% in October but has declined since. A contract performance notice has been in place with EKHUFT and remedial action plans are being monitored. An improvement trajectory has been agreed as part of the planning process with the expectation that compliance will be achieved in September 2016. The CCG has commissioned sufficient activity for 2016/17 to meet anticipated demand and achieve the RTT standard.

% cancer patients waiting under 62 days from referral to treatment	72%	85%	Performance has been consistently below the standard and EKHUFT is subject to a contract performance notice. Remedial actions are underway and an improvement trajectory has been agreed which forecasts compliance by June 2016.
Out of Hospital			
MRSA pre 48hrs	1	0	One case in August, occurred in an elderly gentleman in a care home. The post infection review panel identified the following actions: • Supporting residential care home staff to identify and manage symptoms of deterioration in service users. • Ensuring clinician involvement in planning and implementing EOL care plans. • Communication with out of hours providers and emergency services to ensure appropriate decisions are made. These actions have been shared with the relevant providers.
Dementia diagnosis rate	61.1%	67%	Dementia diagnosis rates improved steadily throughout the year and the CCG implemented innovative schemes to try to identify patients, these included visits to care homes by a consultant psychiatrist. The focus continues to be on particular practices, but care home work suggests that the estimated dementia prevalence for Thanet may be overstated.
% inpatients on CPA followed up within 7 days	93.8%	96.9%	Performance is monitored monthly through contractual meetings with KMPT. Concerns have been raised that a large proportion of patients who aren't on CPA are not followed up within 7 days and the intention is to

			monitor improvement over 2016-17.
IAPT: % of patients accessing IAPT	25%	15%	Access rates have been consistently high in Thanet.
IAPT: % of patients moving to recovery	49.2%	50%	A slight dip in performance this year. This is being investigated, but some indication that some of the patients being treated should not be accepted by IAPT providers as they require a broader package of care. This is being discussed with the new IAPT providers to ensure patients receive the most appropriate care for them. Progress continues to be monitored with IAPT providers on a monthly basis.
IAPT: % of patients entering treatment within 6 weeks of referral	67.7%	75%	This was a new indicator in 2015/16 and local data was not initially available. More recently, with local data now available, one particular provider is struggling to meet the standard. There is a suggestion that patient choice is affecting performance more significantly in Thanet than it does in other areas and this is being investigated.
IAPT: % of patients entering treatment within 18 weeks of referral	99.4%	95%	Performance against this new indicator has been in excess of the standard.
% of adults referred with a first episode of psychosis who receive treatment from EIP services within 2 weeks of referral	Data not available	50%	KMPT is currently unable to report performance. This is partly due to technical issues with data systems but also because KMPT EIP treatment does not meet the NICE guidelines. Reporting is expected to commence in 2016/17. This will be monitored closely as through monthly contractual meetings.

Financial performance		
QIPP	75.8%	The CCG QIPP achievement allowed it to meet its statutory requirements to produce a 1% surplus.
Better Care Fund (BCF) metrics	Thanet CCG has met planned reduction in admissions to residential and nursing care homes, and improvement in patients feeling supported to manage their conditions. Non elective admission rates, delayed transfers of care and injuries due to falls have not shown expected levels of improvement.	

Improving quality

Central to our strategic approach is the ambition to deliver quality related improvement whilst reducing spend. There is commitment across the local health and social care system to develop and deliver integrated care via a new model of care that ensures alignment of commissioner and provider plans. The areas of attention will be:

- Focus on specific health needs and areas of pressure identified in our strategy
- Support the level of integration we expect between our hospital and out of hospital service providers
- Support the system change we require to make the local health system fit for the future.

The areas of focus to help the CCG to achieve this include:

Respiratory	Over 75 years with LTC	Diabetes	CVD
Work collaboratively to embed and measure performance of new integrated care pathway for COPD patients, with ultimate aims being to; • Reduce non-elective admission / re-admission By; • Delivering care close to home • Improving transfer of care • Improving self-management	Embed and measure performance, with ultimate aims being to; • Develop a collaborative shared care plan approach • Improve transfer of care between providers • Improve the safety and quality of patient care	Embed and measure performance, with ultimate aims being to; • Reduce non-elective admission / re-admission By; • Delivering care close to home • Improving transfer of care • Improving self-management	Work collaboratively to embed and measure performance of new integrated care pathway for Heart Failure patients, with ultimate aims being to; • Reduce non-elective admission / re-admission By; • Delivering care close to home • Improving transfer of care • Improving self-management

Parity of Esteem

To further support our strategic ambition to close the gap between mental and physical health, we have devised 3 local quality incentives with our main mental health service provider, Kent and Medway Partnership Trust (KMPT). The quality incentives will;

- Focus on specific health needs and areas of pressure identified in our strategy
- Support the level of integration we expect between our hospital and out of hospital service providers
- Support the system change we require to make the local health system fit for the future

Focus within mental health includes:

Transition from adolescent to Adult Mental Health care	Dementia	Crisis Plans
Full implementation of safe effective transition pathway for adolescence from CAMHS to adult mental health services	Full implementation of ratified multi-agency integrated pathway for patients with Dementia	Full implementation of agreed % crisis plans across key acute cluster pathways. Reduced crisis episodes and unplanned admissions

Improving the quality of services and patient experience is a key issue in all we do. We formally monitor the quality and performance of the services we commission so that we can provide assurances to the Governing Body about the safety of commissioned services, During the year, we undertook a Deep Dive into Accident and Emergency at the local acute hospital, the outcome of which was reported to the Governing Body. The Quality and Operational Leadership Team reviews Serious Incidents and Never Events to identify whether adequate learning has taken place before agreeing to close the incidents. The HCAI assurance panel, a partnership of primary care, the CCG and the hospital has continued to review the most complex cases of Health Care Acquired Infections including C. Difficile and MRSA bacteraemia.

Sustainable Development

The CCG is required to report its progress in delivering against sustainable development indicators. The CCG continues to strive towards achieving its sustainable development aims and principles: Ensuring a strong, healthy and just society

- Living within environmental limits
- Achieving a sustainable economy
- Promoting good governance
- Using sound science responsibly

The CCG is looking to work towards developing a more joined up approach to health and social care and ensuring care is made available locally where possible. The Integrated Accountable Care Organisation (IACO) is a programme of work being developed that will see a more streamlined care pathway for the patient where care needs are able to be met simultaneously. It requires health and social care services to be organised locally so that they can work optimally together in designing integrated pathways which deliver the best outcomes and experiences for patients and offer best value for the tax payer.

Using the NHS Standard Contract, we require our providers to state how they are supporting sustainable development. The CCG is engaged, through the Health and Wellbeing Board and other local agencies, with resilience planning and creating a secure infrastructure that will help the local community remain sustainable when faced with sudden or disruptive events.

The CCG is committed to minimising, where possible, domestic waste while at the same time increasing recycling out-put. This is managed through the encouragement of a paperless office and other waste reduction initiatives such as food waste bins in offices. The CCG continues to support staff to adopt more sustainable ways of working, e.g. providing internet based meeting papers removing the requirement to print papers.

The CCG is continuing to look to implement a sustainability policy that will integrate sustainability considerations into all commissioning decisions by ensuring suppliers, partners and providers are aware of the sustainability policy and encouraging them to adopt appropriate sustainability management practices, e.g. through the tendering process and contract management.

We will develop plans to assess risks, enhance our performance and reduce our impact. We will ensure the Clinical Commissioning Group complies with its obligations under the Climate Change Act 2008, including the Adaptation Reporting power, and the Public Services (Social Value) Act 2012. In the coming year, we will identify how we can contribute to deliver the Sustainable Development Strategy published in February 2014 by NHS England. We will focus on how we can encourage our staff to adopt sustainable habits personally; and we will review how as an organisation the CCG can adopt sustainable approaches to its business.

We are also setting out our commitments as a socially responsible employer.

Public and Patient Engagement

The CCG has a statutory duty to involve patients and the public in commissioning planning and decisions (Section 14Z2 of the National Health Service Act 2006 as amended). We are also required to report on how we have fulfilled our public involvement duty which we do throughout the report but particularly in this section.

How Community Engagement Works

The CCG has a Lay Member for Patient and Public Involvement on the Governing Body. He reports to the Governing Body at every meeting and brings questions raised by the Health Reference Group.

Patient Participation Groups

Since 1 April 2015, it has been mandatory for each GP practice in England to have a patient participation group (PPG). Thanet CCG's Lay Member for Patient Engagement has contacted Thanet GP surgeries and has offered to meet each of their respective PPGs whose role is to:

- Provide a vital link between the CCG and local patients

- Co-ordinate views and issues from individual practice groups

- Working with the CCG to help plan and evaluate local health services

Health Reference Group

Thanet CCG has a collective reference group comprising representatives from the local GP surgery PPGs known as the Thanet Health Reference Group. This group meets on a quarterly basis to give the CCG direct feedback and support for its plans. So far they have discussed medicines management and how to reduce medicines waste, commissioning and the CCG's current priorities, and they have heard about self-care, personal health budgets (PHBs) and the stroke review.

The group also helps members to network and talk about their PPG activities in support of their GP practices, as well as highlighting any issues which their patients have reported about the wider health and social care services.

Public Meetings

Members of the public are welcome to attend any of the CCG Governing Body meetings held in public to ask questions. Special public events are also organised as required to discuss particular issues.

Redesigning Services with Patients

One of the ways that the public and patients help us is by getting involved at an early stage to give us their views about how we can improve the services we commission. In 2015/16 some examples of this include:

➢ Patient Transport Services

Thanet CCG has been working with the other clinical commissioning groups across

Kent and Medway to re-procure non urgent patient transport services. Forty-five Thanet patients helped to write the Patients' Charter setting out the measures of success people expect from the service and this has become part of the service specification which will be used to monitor and manage the new service. Thanet patients have also taken part in evaluating the tenders for the Kent and Medway patient transport service.

Talking Therapy Services

Thanet CCG, working with the other clinical commissioning groups in east Kent, re-procured talking therapy services which support patients with mild to moderate anxiety, depression and other common mental health problems. As part of this, the Mental Health Action Group and Health Reference Group for NHS Thanet Clinical Commissioning Group have reviewed the specification for the new service and contributed to the work of developing success criteria for it. The work was reported on to the Kent Health Overview and Scrutiny Committee. Service users were involved in the formal evaluation of the potential contractors and so informed the decision on which organisations to appoint.

Review of Wheelchair Services

This is looking at existing experience of services as well as gathering feedback on potential changes, ahead of re-procurement of the service in 2017. A survey has been conducted with people who use wheelchair services and their carers to ask about their experience of and views on the service they have received. A total of 129 responses were received and feedback highlights the following themes:

Review of Wheelchair services: Survey results	
Service	• The majority were positive about the wheelchair service overall citing efficient service, quick assessments and good customer care. • 32% of respondents experienced a delay of more than two months for assessment 61% of those experiencing a delay were not aware of the reason for it. Whilst 54% indicate 'no delay' for service on a

		wheelchair . There was as feeling that we “Need more wheelchair assessors.”
Orders	•	68% of respondents support the orders being prioritised by date and postural/pressure care needs.
Referrals	•	64% of respondents support the possibility of stopping self-referrals for those who already have wheelchairs.
	•	support for implementation of a three strike rule wherby if patients do not turn up three times, they cannot self-refer again.

This feedback will be used in the specification for the re-procurement of the service this year, and service users will again be part of the formal evaluation of bidders within the procurement process.

➢ Personal Health Budgets

Thanet CCG has this year involved a range of service users, carers and GP practices and voluntary organisations in developing plans to offer more people in Thanet a Personal Health Budget (PHB). In November approximately 30 people attended a workshop to share ideas on how the CCG and their partners could work together with local people to support self-care effectively and develop proposals to offer PHBs from April 2016. Learning from the national pilots was shared, with examples from patients who had received one elsewhere.

During the question and answer session some clear concerns emerged around:

- The scale of work around PHBs.
- The amount of money needed to support PHBs including the cost of running scheme, for example the broker service.
- Allocation of funds, and the potential for a phased approach.
- Concern that this shouldn’t adversely affect the existing NHS services or the VCS.

There was also some warm approbation for the idea as an important tool for giving patients choice. Other points raised were that:

- Money should be targeted at mental health service.
- A review process is needed as peoples' needs change over time.
- As a means to overcome short term problems for patients and carers.

Mental health was chosen by a clear majority as the most important area of care to receive support from PHBs. It was agreed that a phased approach was best to manage the risks and develop a robust process.

There has been further work with service providers, patients and the public to help the CCG develop plans for delivery, looking at how to determine who would be eligible, the criteria to be used, and how to determine what people could use their PHB on. There was consensus about the need for a broad access to PHBs for service users, with clear support for individuals using the care programme approach to agree the purpose and outcomes expected by using a PHB. People felt strongly that PHB should be used to extend choice and considered as an addition to, rather than a replacement of, existing services or support. Real life case studies have been used to test people's perceptions and refine the CCG's plans which will be implemented in the new financial year.

All of these will be used to develop the proposals, which will be taken through the internal decision making process and planning in preparation for implementation later in the year.

Learning from Complaints

The CCG welcomes any feedback including complaints, comments or expressions of concern from local people about either our own service or the quality of the services we commission and view them as an opportunity for improvement.

The CCG has been working with our Commissioning Support Unit (CSU) to ensure that any 'lessons learned' are clearly identified when responding to complaints. Further work will be undertaken during 2016/17 to produce a robust monitoring process for the CCG to track that any changes recommended as a result of a complaint are indeed subsequently implemented.

The Quality and Operational Leadership Team receives a bi-monthly complaints report which highlights to them the nature of the complaints being received by the CCG as well as the numbers of complaints both received and closed during that timeframe. The committee also reviews a quarterly report, produced by the CCG's Performance Team, of those complaints received by our providers. This provides us with important intelligence which can be used to triangulate the information we have about providers' performance.

The CCG has continued to receive complaints about the delay in processing NHS Continuing Health Care (CHC) retrospective claims as the CCG still has a number of claims outstanding and further to this there have been additional delays with processing payments of those claims where eligibility has been established.

Reducing Inequalities

The CCG has a statutory responsibility to reduce inequalities, working with our Health and Wellbeing Board to do so. Reducing the impact of deprivation on the local population is a "golden thread" throughout the CCG's strategy. The CCG regularly reviews information reported through Right Care[3] tools such as the Atlas of Variation. Through the use of Right Care tools, the CCG has also identified areas where healthcare may not be as good as in other parts of the country:

- Poor outcomes for patients with cancer and circulatory disease, and care provided is costly;
- Care for patients with diabetes has better outcomes and is cheaper in other CCGs with a similar demographic;
- Care for gastrointestinal and neurological conditions is more expensive in Thanet than in other similar CCGs;
- High numbers of under 5 year-olds are being admitted to hospital;
- There are high rates of emergency admissions to hospital for people over 75 which are potentially avoidable;

[3] http://www.rightcare.nhs.uk/

- Significant rise in delayed transfers of care from hospital.

The Thanet Health and Wellbeing Board has made reducing inequalities a priority and has established an inequalities sub-group to address the issues. This group is clinically led and includes commissioners and providers from across the system. The Group is using Right Care data to develop an action plan which will deliver solutions for the areas of greatest inequality in Thanet.

A cancer strategy and action plan have already been developed and a key focus is improving the uptake of screening. Providers of lifestyle services will offer greater support in certain deprived areas, such as Cliftonville and Newington, to promote healthier lifestyles. A campaign targeting those in the most deprived communities who have the poorest outcomes relating to cancer is also planned.

Hazel Carpenter
Accounting Officer
25 May 2016

Accountability Report

I. Members Report

NHS Thanet Clinical Commissioning Group (CCG) was established in April 2013 under the Health and Social Care Act 2012 as a body corporate.

How the CCG Works: Our Business Model

There are 17 Member Practices belonging to Thanet CCG following the closures of both Cecil Square surgery in September 2015 and Osbourne Road surgery in December 2015. Additional changes in 2015/16 included a change of name for The Albion Surgery which is now known as the Broadway Medical Practice from August 2015.

1. Bethesda Medical Centre	2. Birchington Medical Centre
3. Broadway Medical Practice	4. Dashwood Medical Centre
5. East Cliff Medical Practice	6. Garlinge Surgery
7. Minster Surgery	8. Mocketts Wood Surgery
9. Newington Rd Surgery	10. Northdown
11. St Peter's Surgery	12. Summerhill Surgery
13. The Grange Medical Centre	14. The Limes
15. Union Row Surgery	16. Westgate Surgery
17. Wickham Surgery	

For Further details, please see NHS Thanet CCG's website: www.thanetccg.nhs.uk

Governing Body Members

Dr Tony Martin has been chair of the CCG since it was established, up to and including the time of signing the Report and Accounts. Hazel Carpenter has been the Accountable Officer for the same period.

NHS Thanet CCG's Governing Body has a very strong clinical membership and focus, with a GP as Chair and five additional elected GP Governing Body members, along with a hospital consultant and a nurse member. The Governing Body also includes two independent lay members, and senior members of the CCG management team.

The following have been members of the NHS Thanet CCG up to and including the time of signing of the accounts unless otherwise indicated:

Dr Tony Martin	**Clinical Chair**
Hazel Carpenter	**Accountable Officer**
Jonathan Bates	**Chief Finance Officer**
Dr Mark Elliott	**GP member**
DrJihad Malasi (from 1 Jan 2016)	**GP member**
Dr Adem Akyol	**GP member**
Dr Tariq Rahman (until Nov 2015)	**GP member**
Dr John Neden	**GP member**
Dr Sabin Kamal (from Nov 2015)	**GP member**
Dr Devaka Fernando	**Secondary Care Doctor**
David Lewis	**Lay member with responsibility for Governance**
Clive Hart	**Lay member with responsibility for Public Engagement**
Sharon Gardner-Blatch	**Chief Nursing Officer**

Details of the senior management team are outlined below:

Hazel Carpenter	**Accountable Officer**
Jonathan Bates	**Chief Finance Officer**
Ailsa Ogilvie	**Chief Operating Officer**
Dr Sue Martin	**Company Secretary**

See page 69 for biographies of the Governing Body members.

The Governing Body has a number of committees to help conduct its business. Their responsibilities are set out in the Constitution and summarised in the Annual Governance Statement by the Accountable Officer.

Compliance Statements

Responsibility for Audit

The Governance and Risk Committee discharges the responsibility of an audit committee. The following have been members of the Governance and Risk Committee in Thanet up to and including the time of signing the accounts:

David Lewis	**Chair, Lay Member for Governance and Risk**
Clive Hart	**Lay Member for Patient Engagement**
Alistair Smith	**Independent Co-opted Member**
Stewart Coltart	**Secondary Care Doctor**

The external auditors, Grant Thornton, and the internal auditors, Tiaa Ltd both attend the Governance and Risk Committee and regularly meet separately with the members of the Committee.

External Audit

The Audit Commission appointed Grant Thornton as the external auditors of the CCG. The contract value for this work is £55,620 for 2015/16

Statement as to Disclosure to Auditors

The Governing Body delegated responsibility for approving the Annual Report and Accounts to the Governance and Risk Committee. Each Member of the Governance and Risk Committee has stated, confirmed by the minutes that as far as they are aware there is no relevant audit information of which the CCG's auditors are unaware. Each Member has taken all steps that they think necessary as a member of the Governing Body and the Governance and Risk Committee to make themselves aware of any relevant audit information and establish that the CCG's auditors are aware of that information. This was confirmed by the Governing Body Members at the meeting of the Governing Body meeting on 10th May 2016.

Members Interests

The register of interest for Thanet CGG's Governing Body members can be found on our website; www.thanetccg.nhs.uk.

Pension Liabilities

The CCG provides pensions for staff and for GP Elected Members on the Governing Body under the NHS Pension scheme. This is a 'Pay as you earn' scheme and follows international accounting practice. The basis of the accounting treatment is set out in the statutory financial statement within the CCG's accounting policies section of the accounts.

Control measures are in place to ensure all employer obligations contained within the scheme regulations are complied with. This includes ensuring that deductions from salary, employer's contributions and payments into the scheme are in accordance with the scheme rules, and that member pension scheme records are accurately updated in accordance with the timescales detailed in the regulations.

Equality, Diversity & Human Rights Obligations

The CCG acknowledges its responsibilities under the Equality Act 2010 and the Human Rights Act 1998 and associated equality legislation. It strives to:

- eliminate discrimination, harassment and victimisation and any other conduct that is prohibited by or under the Equality Act
- advance equality of opportunity between people who share a relevant protected characteristic and people who do not share it
- foster good relations between people who share a relevant protected characteristic and those who do not share it

The CCG has policies in place to ensure that there is no discrimination of any individual or group on the grounds of age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex, and sexual orientation.

The CCG is also required to publish information demonstrating its compliance with the general duty by 31st January each year and will also publish one or more equality objectives by 6th April each year.

Data Protection: Cost AllocatIon and Setting of Charges for Information

The CCG has received one Subject Access Request under the Data Protection Act, however this was for records for which the CCG is not the Data Controller and therefore we were unable to comply with this request. We certify that the CCG is aware of HM Treasury's guidance on cost allocation and the setting of charges for information however, the CCG will rarely apply charges as the amounts are considered too small to offset against raising an invoice.

Disclosure of Personal Data Related Incidents

The CCG has a policy for dealing with Serious Untoward Incidents in its Risk Management Policy. The CCG uses the IG Toolkit Incident Reporting Tool to report IG SIRIs to the Health and Social Care Information Centre (HSCIC), Department of Health, ICO and other regulators. In the Annual Governance Statement, the Accountable Officer has declared that there were no Serious Untoward Incidents in 15/16.

Health and Safety

The SECSU provides Health and Safety support to the CCG and has responsibility for the annual review of the CCG's premises at Thanet District Council to ensure compliance with statutory guidelines.

The CCG's Health and Safety Adviser also undertakes desk assessments for all new members of staff, and then as required by all staff. They will attend the Staff Engagement Forum to report regularly on developments and issues relating to health and safety.

There has been one accident reported at work during 2015/16.

Counter Fraud

NHS Thanet CCG has an Anti-Fraud Bribery and Corruption Policy. In 2015 TIAA Ltd, the internal auditors, conducted another benchmarking survey amongst staff about awareness of fraud and whistleblowing which showed a relatively good response. However, further training is needed to improve awareness of how to go about raising a concern.

The counter fraud exercise to ensure the information on all staff files is up-to-date continued throughout 2015/16, this required all staff to meet with the Counter Fraud Support Officer who made relevant checks to ID and documentation.

Better Payments Practice Code

The Better Payment Practice Code requires the CCG to aim to pay all valid invoices by the due date or within 30 days of receipt of a valid invoice, whichever is later.

On 1 April 2013 the CCG became an approved signatory of The Better Payment Practice Code. The initiative was devised by the government with The Institute of Credit Management (ICM) to tackle the crucial issue of late payment and to help small businesses. Suppliers can have confidence in any company that signs up to the code that they will be paid within clearly defined terms, and that there is a proper process for dealing with any payments that are in dispute.

Approved signatories undertake to:

- Pay suppliers on time.
- Give clear guidance to suppliers and resolve disputes as quickly as possible.
- Encourage suppliers and customers to sign up to the code.

Details of the compliance with the code are given in note 6.1 to the accounts.

In 2015/16 compliance with the Code was as follows:

	Number of invoices	Value of invoices
Non NHS	96%	98%
NHS	98%	99%

Prompt Payments Code

Thanet CCG has also signed up to the prompt payment code.

Emergency Preparedness, Resilience and Response

The CCG has in place incident response plans and business continuity plans to ensure its business can continue in the event of a major emergency. The CCG is a member of the Local Health Resilience Forum and the Kent Resilience Forum. The CCG has taken part in a number of exercises to ensure it is prepared for emergencies. It engages with partners to review its response to emergencies including health protection incidents and flu pandemics.

We confirm that the CCG has an updated incident response plan in place that was approved by the Governing Body in December 2015 and is fully compliant with the NHS Commissioning Board Emergency Preparedness Framework 2013. The CCG regularly reviews and makes improvements to its major incident plan and has a programme for regularly testing the plan, the results of which are reported to the Governing Body.

Principles for Remedy

As part of its complaints procedures, the CCG has set out the steps it will take should it cause injustice or hardship by maladministration or by service failure. The steps are as follows:

- The CCG will acknowledge and put right cases of maladministration or poor service that have led to injustice or hardship.
- The CCG will apologise for and explain the maladministration or poor service and understand and manage people's expectations and needs.
- The CCG will be open and clear about how public bodies decide remedies, operating a proper system of accountability and delegation in providing remedies.
- The CCG will offer remedies that are fair and proportionate to the complainant's injustice or hardship and provide remedy to others who have suffered injustice or hardship as a result of the maladministration.
- The CCG will, if possible, return the complainant and where appropriate others who have suffered similar injustices or hardship to the position they would have been if the maladministration or poor service had not happened.
- The CCG will use the lessons learned from the complaints to ensure that maladministration or poor service is not repeated and services are improved.

ACCOUNTABILITY REPORT – CORPORATE GOVERNANCE REPORT

I.STATEMENTS BY THE ACCOUNTABLE OFFICER

Statement of the Responsibilities as the Accountable Officer of NHS Thanet Clinical Commissioning Group

The NHS Act 2006 as amended states that each Clinical Commissioning Group shall have an Accountable Officer and that Officer shall be appointed by the NHS Commissioning Board (NHS England). NHS England has appointed Hazel Carpenter to be the Accountable Officer of the Clinical Commissioning Group.

The responsibilities of an Accountable Officer, including responsibilities for the propriety and regularity of the public finances for which the Accountable Officer is answerable, for keeping proper accounting records (which disclose with reasonable accuracy at any time the financial position of the Clinical Commissioning Group and enable them to ensure that the accounts comply with the requirements of the Accounts Direction) and for safeguarding the Clinical Commissioning Group's assets (and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities), are set out in the *Clinical Commissioning Group Accountable Officer Memorandum* published by NHS England.

Under the NHS Act 2006 (as amended), NHS England has directed each Clinical Commissioning Group to prepare for each financial year financial statements in the form and on the basis set out in the Accounts Direction. The financial statements are prepared on an accruals basis and must give a true and fair view of the state of affairs of the Clinical Commissioning Group and of its net expenditure, changes in taxpayers' equity and cash flows for the financial year.

In preparing the financial statements, the Accountable Officer is required to comply with the requirements of the Government's Manual for Accounts and in particular to:

- Observe the Accounts Direction issued by NHS England, including the relevant accounting and disclosure requirements, and apply suitable accounting policies on a consistent basis;
- Make judgements and estimates on a reasonable basis;
- State whether applicable accounting standards as set out in the Manual for Accounts have been followed, and disclose and explain any material departures in the financial statements; and,
- Prepare the financial statements on a going concern basis.

To the best of my knowledge and belief, I have properly discharged the responsibilities set out in NHS England's *Clinical Commissioning Group Accountable Officer Memorandum*.

Hazel Carpenter
Accountable Officer
25 May 2016

III.ANNUAL GOVERNANCE STATEMENT: 2015/16

The Thanet Clinical Commissioning Group was licensed from 1 April 2013 under provisions enacted in the Health & Social Care Act 2012, which amended the National Health Service Act 2006.

As at 1 April 2015, the Clinical Commissioning Group (CCG) was rated as “assured with support” by NHS England (NHSE). NHSE has concluded that the CCG continued to make steady progress and was able to articulate a clear 5 year vision and good engagement with local people. However, it required the CCG to keep pressure on the local providers whose continued poor performance continued to compromise high quality services and better outcomes for local people. The performance of its providers continues to be a challenge for the CCG. At this point, the members of the CCG have decided not to undertake co-commissioning of primary care services but will keep this decision under review.

Scope of Responsibility

As Accountable Officer, I have responsibility for maintaining a sound system of internal control that supports the achievement of the CCG’s policies, aims and objectives, whilst safeguarding the public funds and assets for which I am personally responsible, in accordance with the responsibilities assigned to me in *Managing Public Money*. I also acknowledge my responsibilities as set out in my CCG Accountable Officer Appointment Letter. I am responsible for ensuring that the clinical commissioning group is administered prudently and economically and that resources are applied efficiently and effectively, safeguarding financial propriety and regularity.

Compliance with the UK Corporate Governance Code

The CCG is not required to comply with the UK Corporate Governance Code. However, I have reported on our corporate governance arrangements by drawing upon best practice available, including those aspects of the UK Corporate Governance Code I consider to be relevant to the clinical commissioning group and best practice. During the year, the Governing Body reviewed how effectively it complied with its statutory responsibilities. The Governance and Risk Committee has undertaken a review of the CCG's governance using the Good Governance Institute Toolkit and will follow this up with a more detailed review in two specific areas in 2016/17 to ensure the CCG's governance arrangements continue to remain robust.

The Clinical Commissioning Group Governance Framework

The National Health Service Act 2006 (as amended), at paragraph 14L(2)(b) states:

The main function of the governing body is to ensure that the group has made appropriate arrangements for ensuring that it complies with such generally accepted principles of good governance as are relevant to it.

Our Constitution, which is published on our website, sets out the governance arrangements we have established for ensuring that we make decisions openly and transparently, based on an assessment of clinical need, for ensuring that we meet our financial and statutory obligations, and for ensuring that we manage and control risk effectively. The CCG's Constitution has been approved by NHS England. During 2015/16, parts of the Constitution were reviewed, including the terms of reference for all the Committees and the conflicts of interest policy. I have asked the Governance and Risk Committee to oversee further revisions to the Constitution during 2016/17 to ensure it remains fit for purpose for the future.

The Membership

The CCG is a membership organisation comprising the 17 General Practices in the area of Thanet (see Members' Report, Page 36). Each Member Practice has signed up to the Constitution of the CCG which sets out the Vision and Values of Thanet CCG and has agreed to participate actively in its work. Each Practice is represented by a Lead, a clinical professional, whose role is to represent the views of their Practice and act on the Practice's behalf in respect of matters discussed by the CCG.

During the year, the Members were asked to appoint a number of GP Elected Leads to represent them on the Governing Body and its committees. The Members meet as a Clinical Commissioning Group regularly throughout the year. At the Membership meetings, the Governing Body accounts to the membership for its implementation of the CCG's strategy and takes the members' views on important issues, including prescribing costs and the future of primary care in Thanet.

As well as providing strategic support to the organisation, the Members are actively involved in the activities of the CCG. In addition to the Governing Body members, there are several local GPs who actively engage with the CCG as clinical leads. They provide clinical leadership for aspects of the CCG's commissioning strategy, including (for example) mental health, primary care and children's health. It remains the members' responsibility to approve the CCG's strategy and engage with and listen to the perspectives of patients expressed through the Patient Participation Groups.

The Members have continued to guide the development of the CCG's approach to the Integrated Accountable Care Organisation, as part of which four localities have been established, in Margate, Ramsgate, Broadstairs and Quex. In each locality, the members are involved in redesigning services at a local level to ensure that care is wrapped round the patient. At the end of 2015 it was announced that Thanet had successfully bid to become one of the fifteen national rapid test sites for the Primary Care Home - a form of multispecialty community provider (MCP) model. More information about the localities is included at page 16.

The Governing Body

The Governing Body is tasked by the Members with ensuring that the CCG has adequate arrangements in place to deliver the CCG's strategic direction, to monitor its performance and to meet its statutory responsibilities. All Governing Body Members have equal and joint responsibility for governing the activities of the CCG and in being accountable to the Membership and the public for the way in which it discharges its functions.

The CCG's scheme of delegation and Committee Terms of Reference set out the level of delegation to the Governing Body from the Membership.

The Governing Body met 3 times during 2015/16 in public and 5 times in private session. At its meetings, the Governing Body

- Continued to refine the priorities in the Thanet Plan and to monitor its implementation.
- Scrutinised the performance of the CCG'S main providers including the quality of primary care through a primary care dashboard.
- Regularly discussed the development of the Integrated Care Organisation and the Health and Wellbeing Board, both of which are vital to the CCG's future strategy.
- Approved several procurement exercises, including for Integrated Community Equipment Store, Patient Transport Service and the Out of Hours/111 NHS and Care Navigation service.
- Heard regularly about engagement activities with local people and with the membership and used these reports to underpin its decision-making processes.
- Approved key CCG documents including the Risk Management Policy, the Whistleblowing Policy, revised terms of reference for its committees, and kept the Risk Register and Assurance Framework under review.
- Received reports of the CCG's partnerships with the Kent Health and Wellbeing Board; the East Kent System Resilience Group, the East Kent Strategy Board and the East Kent Federation; and the Thanet Health and Wellbeing Board.

The membership of the Governing Body is included in the Members' Report. I report on their attendance at Governing Body meetings below. Dr Joseph Braga was appointed to the Governing Body for 1st April 2015 but was unable to take up his appointment. Dr Tariq

Rahman stood down in November 2015. Two new members were appointed to replace both: Dr Sabin Kamal and Dr Jihad Malasi who took up their roles on 1 November and 1st January 2016 respectively.

Thanet Governing Body Members' Attendance at Public Meetings

GB MEMBER	14/07/15	08/12/15	08/03/16	TOTAL
Tony Martin	√	√	√	3/3
Hazel Carpenter	√	√	√	3/3
Jonathan Bates	√	√	√	3/3
Devaka Fernando		√	√	2/3
Mark Elliott	√	√	√	3/3
Sabin Kamal (from 1 November 2015)		√	√	2/2
Adem Akyol	√	√	√	3/3
Tariq Rahman (until 13 November 2015)				0/2
David Lewis	√	√	√	3/3
Clive Hart	√	√	√	3/3
Sharon Gardner-Blatch		√	√	2/3
John Neden	√	√	√	3/3
Jihad Milasi (from 1 January 2016)			√	1/1

All Governing Body members, CCG Members and members of staff are required to record annually any interests which are relevant to their role on the CCG. The register of interests is updated each quarter and is a public document on the CCG's website. During the year, we asked those in a position in GP practices to take decisions regarding expenditure and contracts to declare interests, which are also on the CCG's website. http://www.thanetccg.nhs.uk/home/#

Managing potential conflicts of interest is important because GPs as Governing Body members are involved in taking decisions about the provision of services, from which they may benefit as members of GP practices. The CCG has adopted a Code of Conduct for GPs relating to procurement where GP practices may also be providers of services. The CCG has revised the Conflicts of Interest policy to give the Governance and Risk Committee a larger role in monitoring the recording of interests, including by GP practices, and in monitoring decisions about procurement. It also provides advice to the Clinical Chair and Accountable Officer on how to manage interests so that the CCG can ensure that decisions about procurement are taken on a strong clinical basis, transparently and with the best interests of the local population in mind.

The CCG's Organisation Development Plan has concentrated on strengthening the wider clinical leadership of the CCG and improving the CCG's analysis of data in order to provide a more effective focus on performance.

The Clinical Chair has discussed the performance of the GP Elected Leads on the Governing Body throughout the year.

Committees of the Governing Body

The Committees established by the Governing Body are as follows:

- The Clinical Leadership Team
- Quality and Operational Leadership Team
- The Governance and Risk Committee
- The Remuneration and Nominations Committee.

The Clinical Leadership Team (CLT) met monthly during 2015/16. It has taken the lead role in overseeing the development and implementation of the strategic priorities in the Thanet Plan.

At every meeting the Committee has received an update about developments "In Hospital", and in Integrated Care (including primary care), mental health, dementia, children's services, public health and prescribing.

- CLT considered a number of key clinical issues, including cancer strategy, an update on stroke services, End of Life Pathway, CAMHS specification, Over 75s project and the project on Discharge to Assess.

The Committee reviewed its terms of reference and undertook an assessment of its effectiveness. It agreed that it covered the clinical issues well but wanted to be more forward looking in its discussions and to monitor the implementation of the key strategies which will enable the CCG to move forward.

Members of Clinical Leadership Team

NAME	ROLE	ATTENDANCE (out of 12 meetings)
Dr Tony Martin	Chair	12
Dr Adem Akyol	GP Member	11
Dr Mark Elliott	GP Member	8
Dr John Neden	GP Member	11
Dr Tariq Rahman	GP Member until 13 November 2015	5/8
Dr Sabin Kamal	GP Member from 1 November 2015	1/5
Dr Jihad Malasi	GP Member from 1 January 2016	1/3
Prof Devaka Fernando	Secondary Care Doctor	5
Hazel Carpenter	Accountable Officer	9
Jonathan Bates	Chief Finance Officer	6
Ailsa Ogilvie	Chief Operating Officer	10
Sharon Gardner-Blatch	Chief Nursing Officer	8
Colin Thompson	Public Health Consultant	9

The Quality and Operational Leadership Team (QOLT) also met on a monthly basis during 2015/16. Its focus was on monitoring the in-year performance of providers commissioned by the CCG and of the CCG itself. The Committee:

- Reviews the management of risks and the CCG's financial position and receives regular reports on complaints, safeguarding adults and children, Looked After Children and Transforming Care.
- Has lead responsibility for reviewing safety and quality, considering patient experience, for closing Serious Incidents and reviewing "Never Events" to identify improvements and learning. During the year, the Committee gained the Governing Body's approval to establish a sub-group which reviews the Serious Incidents received by the CCG on the Committee's behalf. The Committee retains the decision as to whether a Serious Incident can be closed.
- Strengthened its oversight of provider quality and performance. The Integrated Quality and Performance Report (IQPR) has continued to highlight key performance and quality concerns and triangulate those concerns with other data for all the CCG's providers and the CCG's constitutional targets. It is a key tool enabling the Committee to identify issues which need to be raised with providers at an early stage so that the providers can address these.
- The intelligence in the IQPR has also informed the discussion in Contract Delivery meetings and in several instances has resulted in the issue of a Contract Query Notice to providers to improve performance. The Committee has been particularly concerned about the performance of A&E at Queen Elizabeth Queen Mother (QEQM) hospital and about the 62 day wait target for cancer. These are reported upon in the Performance section of the Annual Report (page 23). The data also informs the CCG's decisions to undertake quality visits and deep dives, for example, into maternity services and into A&E.
- Now reviews the performance of primary care using a primary care dashboard, and of nursing homes in the area.
- Has also reviewed its terms of reference and considered its effectiveness as a Committee in discharging its responsibilities. The Committee agreed that, to help it manage its very large agenda, it would establish a sub-group to review Serious Incidents in detail before they are presented to the Committee for decision on whether to close.

Members of Quality and Operational Leadership Team

NAME	ROLE	ATTENDANCE (out of 10 meetings)
Hazel Carpenter	Accountable Officer	9
Dr Tony Martin	Chair	7
Dr Adem Akyol	GP Member	5
Dr Mark Elliott	GP Member	9
Dr John Neden	GP Member	6
Dr Tariq Rahman	GP Member until 13 November 2015	0
Dr Sabin Kamal	GP Member from 1 November 2015	0/3
Dr Jihad Malasi	GP Member from 1 January 2016	3/3
David Lewis	Lay Member, Governance	10
Clive Hart	Lay Member, PPE	10
Jonathan Bates	Chief Finance Officer	8
Ailsa Ogilvie	Chief Operating Officer	5
Sharon Gardner-Blatch	Chief Nursing Officer	6
Louise Pilcher	Practice Manager	3/6
Dr Sue Martin	Company Secretary	10

The **Governance and Risk Committee** is charged with providing independent assurance to the Governing Body that the CCG's systems of risk management, internal control and governance are effective. These include the CCG's arrangements for preventing corruption and for countering fraud.

The Governance and Risk Committee has met jointly with the NHS South Kent Coast CCG Governance and Risk Committee 5 times during 2015/16. The Committee is alternately chaired by the Lay Member for Governance of each CCG.

The Lay Member for Public and Patient Engagement is a member of the Committee as is the secondary care doctor for South Kent Coast CCG. The Committee meetings are attended by the External Auditors, the Internal Auditors, the Chief Finance Officer, the Chief Nursing Officer and the Company Secretary.

The Committee Chair has financial expertise and the Chief Nursing Officer and the Secondary Care Doctor provide expertise in clinical effectiveness and quality.

- The Committee has performed a number of key tasks at my request, providing assurance to me through their independent scrutiny and challenge. I asked the Committee to keep the CCG's arrangements for providing assurance to NHS England under review. The Chair of the Committee completed several submissions required by NHS England, including an assessment of the CCG's financial control environment.

- The Committee's annual work plan has been approved by the Governing Body. The Committee reviewed a number of policies before these were submitted to the Governing Body for approval, including the risk management policy, the whistleblowing policy and gifts and hospitality policy.

- It reviewed the operation of the Conflicts of Interest Policy, the use of Single Tender Waivers and undertook a review of a contracting exercise on DVT. As a result of each of these reviews, the Committee made recommendations for improvement to the Governing Body.

- The Committee reviewed the risk register and assurance framework at each meeting and heard regularly from the internal auditors, Tiaa Ltd, who have responsibility for advising the Committee on whether the control arrangements which the CCG has in place are adequate. The Committee also received reports from the Counter Fraud Service.
- The Committee received reports from the external auditors, Grant Thornton, who are required to perform the CCG's audit and in accordance with the Code of Practice issued by the National Audit Office (NAO) on behalf of the Comptroller and Auditor General in April 2015. The external auditors' responsibilities under the Code are to:
  - give an opinion on the CCG's financial statements
  - give an opinion on the regularity of expenditure and income recorded in the CCG's financial statements
  - satisfy themselves that the CCG has made proper arrangements for securing economy, efficiency and effectiveness in its use of resources

based on the following criterion: In all significant respects, the audited body had proper arrangements to ensure it took properly informed decisions and deployed resources to achieve planned and sustainable outcomes for taxpayers and local people.

The Governance and Risk Committee reviewed its terms of reference and undertook a review of its effectiveness as a Committee. The Committee concluded that it was working reasonably well, but there was also consensus about some areas for improvement, included ensuring that the accounting policies were reviewed as part of the annual accounts process. They submitted an annual report to the Governing Body which is published on the CCG's website.

Governance and Risk Committee Members

MEMBER	ROLE	ATTENDANCE (out of 5 meetings)
David Lewis	Committee Chair	5
Clive Hart	Lay Member PPE	5
Alistair Smith	Co-opted Lay Member	5
Dr Stewart Coltart	Co-opted Secondary Care Doctor	5

The **Remuneration and Nominations Committee** has met three times during 2015/16. The Committee has responsibility for making recommendations to the Governing Body on remuneration of members of the Governing Body and senior employees of the CCG, advising on contractual arrangements for the same group of people, developing an approach to succession planning and ensuring that the Governing Body has the right balance of skills and knowledge. It is chaired by the Lay Member for Governance.

The Committee

- Heard from the Clinical Chair about the effectiveness of the clinical members of the Governing Body and from myself as Accountable Officer on the performance of senior members of the CCG staff
- Reviewed the rates of pay for the Governing Body
- Agreed the training which would be mandatory for Governing Body members
- Considered succession planning including the skills needed on the Governing Body
- Reviewed its terms of reference
-

Remuneration Committee Members

MEMBER	ROLE	ATTENDANCE (out of 3 meetings)
David Lewis	Committee Chair	3
Clive Hart	Lay Member PPE	3
Tony Martin	Clinical Chair	3

Joint Committees

The CCG has not established a Joint Committee.

The CCG's Risk Management Framework

Key elements of the risk management strategy

The purpose of the CCG's Risk Management framework is to enable the CCG to have a clear view of the risks affecting each strand of its activity and how they should be managed.

The CCG's Risk Management Policy, which sets out responsibilities for identifying and managing risk as well as the arrangements the CCG has in place for opening, rating and closing risks, was reviewed and updated during the year. The Governing Body has overall responsibility for managing risks and assurance and reviews those risks which are rated "red". The Clinical Leads help to identify risks in relation to their clinical area, to design mitigating actions and to ensure that risks are appropriately managed. The Quality and Operational Leadership Team regularly reviews the management of the most significant clinical risks using both the Risk Register and the Integrated Quality and Performance Report. The Governance and Risk Committee is responsible for providing assurance to the Governing Body on the effectiveness of risk management.

The CCG has policies and processes in place to prevent certain risks emerging in the first place, for example through its counter fraud policy, its bribery policy and statement of standards of business conduct, which was reviewed during the year. The CCG's whistleblowing policy provides an opportunity for anyone who has a concern about the conduct of the CCG to raise a concern without fear of repercussions. Governing Body Members are required to declare any conflicts of interest at each meeting. The CCG provides training on its policies and the Counter Fraud specialist from the Internal Auditors reports regularly to the Governance and Risk Committee.

Risk assessment

The CCG has focused more clearly on how risks impact on any one of its strategic objectives. The risk register shows links to the strategic objectives and to the Assurance Framework. Once identified, risks are rated in terms of the likelihood of their occurrence and their impact if they did, using the 5x5 matrix; they are reassessed once the mitigating actions have been identified, leaving the risk score showing the residual risk level to the CCG. A decision is made as to whether the risk can be tolerated or must be treated. If it is to be treated, additional mitigating actions are identified and monitored so that the risk level can be reduced to a tolerable level.

In discussing its appetite for risk, the CCG Governing Body has stated that it has no tolerance for risks where patient safety is at issue, where the ongoing financial viability of the CCG is at issue, or where the CCG's compliance with the law may be adversely affected. The level of risk which can be tolerated in delivering its strategic objectives does vary; for example, the Governing Body is willing to accept a level of risk to promote innovation or where long-term benefits outweigh short term risks; but the CCG scrutinises the level of risk regularly and challenges whether the risk has reduced or why it has remained at the same level for some time.

To help the CCG manage risks, the CCG values the contributions of local people. The CCG monitors complaints made by the public about its services and those of the local providers. It conducts regular discussions and consultations with local people about their experience of health services and involves them in the redesign of services. For example, Thanet hosted a number of discussions with local people on the reconfiguration of stroke services. Local people are able to ask questions and alert the CCG to any risks at the Health Reference Group and at the Governing Body meetings.

The most significant risks identified by the CCG during 2015/16 were:

RISK	ACTION
High number of Looked After Children in Thanet not receiving their statutory health assessments in a timely way. Monitoring provision of services is difficult because of lack of performance data.	The CCG has escalated its concern about the poor performance of providers through issuing a Contract Performance Notice, requiring the providers to detail how they will improve.
The high use of out of area mental health beds results in poor patient experience and increased costs	This risk is being managed through bi-weekly telephone discussions with the provider to find alternatives to out of area placements.
The acute trust has continued to fail to meet constitutional targets, including A&E 4 hour waits, Referral to Treatment in 18 weeks and 62 day cancer wait.	The CCG is working with other CCGs in East Kent to address these performance issues, but has instigated detailed reviews, including by its GP members, to identify where the problems are. This will continue to be a risk in the coming year.
The financial position of the CCG and all the providers in the East	The CCG is addressing this risk through a savings action plan which is monitored

Kent health economy. The CCG has identified a number of high risk areas in its own expenditure, including Continuing Health Care Placements and GP prescribing costs, which it is monitoring. The providers in East Kent face significant deficits which will make achieving agreements about contracts challenging	at every meeting of the Governing Body and the Quality and Operational Leadership Team, monitoring the performance of GPs particularly around prescribing expenditure and working closely with the providers on affordable secondary care strategies, highlighting areas where productivity needs to improve. Where appropriate, the CCG has also put in place formal dispute arrangements for key areas of financial pressure

Other risks are on-going. Due to the profile of the population of Thanet, there are particular challenges which Thanet CCG must address. Of the twelve local authorities in Kent, Thanet is the most disadvantaged. The percentage of the population aged over 65 is high and expected to grow, while at the same time the number of children born in Thanet is increasing. There are high levels of substance and alcohol abuse and high demand for mental health services including for children and older people at a time when the economically productive proportion of the population is declining, all of which make for particular challenges not only for the CCG but for its partners such as the County Council and District Council. The CCG is addressing these challenges by working in partnership particularly with the Thanet District Council and other members of the local Health and Wellbeing Board and agreeing joint strategies for addressing the major issues of inequalities, cancer, and obesity.

The principal risk to the CCG's governance for the coming year is that of the CCG's Constitution keeping pace with the development of greater localism. In line with the NHS Five Year Forward View, the CCG is considering how to achieve more integrated commissioning and more devolved and community based delivery of services. These developments may challenge the scope of delegation currently permitted by NHS England. However, we are in regular discussion with NHSE about our plans and identifying issues where current arrangements constrain our ability to deliver the CCG's vision.

The CCG has improved its analysis of risk and its impact and I expect this to continue in the next year. During 2015/16, steps have been taken to ensure that all Members and staff are aware of how the CCG defines risk and that risk is properly assessed and managed. The CCG discusses partner/provider risks at performance meetings and when negotiating agreements such as s75 agreements.

The CCG's Internal Control Framework

A system of internal control is the set of processes and procedures in place in the CCG to ensure it delivers its policies, aims and objectives. It is designed to identify and prioritise the risks, to evaluate the likelihood of those risks being realised and the impact should they be realised, and to manage them efficiently, effectively and economically. The system of internal control allows risk to be managed to a reasonable level rather than eliminating all risk; it can therefore only provide reasonable and not absolute assurance of effectiveness.

The CCG's system of internal control is a significant part of the assurance framework and is designed to manage risk at a reasonable level. This is particularly important as a number of risks which might undermine the CCG's delivery of its plans are "owned" by providers of services, not directly by the CCG. The Assurance Framework records the primary risks to the ongoing viability of the CCG: the risk of not delivering its strategic objectives, not meeting its financial targets, not delivering the CCG's statutory requirements, not commissioning safe services, not maintaining its authorisation, and not maintaining the support of the CCG membership and the public. The Assurance Framework evaluates the strength of the internal controls in preventing the risk materialising, and identifies gaps in assurance.

The Assurance Framework has been used by the Governing Body to hear from and challenge the Clinical Leads about progress in delivering the objective for which they are accountable. The Assurance Framework is also monitored by the Governance and Risk Committee, the Quality and Operational Leadership Team and the Governing Body.

Impact Assessments, including Equality Impact Assessments and Privacy Impact Assessments, help the Governing Body identify risks which might disproportionately affect various members of the community. Policies and business cases are expected to be presented to the Committee and Governing Body with an appropriate Impact Assessment, particularly an Equality Impact Assessment, to help with identification of risk. The strategies developed by the CCG in partnership, for example the Kent Health and Wellbeing Board's Emotional Wellbeing Strategy, also have an Equality Impact Assessment.

The CCG's policies relating to standards of business conduct make explicit the CCG's expectation that all members and staff will behave in an ethical manner. Internal audit plays a key role in monitoring the effectiveness of the CCG's internal control framework, and has undertaken reviews of critical financial systems, governance processes, and information governance. The Counter Fraud Officer also reviews the effectiveness of the CCG's procedures in preventing and identifying fraud.

The Performance Report contains statements about the CCG's compliance with a number of statutory duties which I have reviewed and which I confirm are correct (see page 67)

Information Governance

The NHS Information Governance Framework sets the processes and procedures by which the NHS handles information about patients and employees, in particular personal identifiable information. The NHS Information Governance Framework is supported by an information governance toolkit and the annual submission process provides assurances to the Clinical Commissioning Group, other organisations and to individuals that personal information is dealt with legally, securely, efficiently and effectively.

In April 2015, the CCG took over the management of its compliance with Information Governance requirements from the South East Commissioning Support Unit. We place high importance on ensuring there are robust information governance systems and processes in place to help protect patient and corporate information. We have established an Information Governance Management Framework and reviewed all the Information Governance policies. We have established an Information Governance Steering Group jointly with South Kent Coast CCG to oversee the completion of audits and reviews which will ensure that the CCG continues to develop information governance processes and procedures in line with the information governance toolkit. We have ensured all staff undertake annual information governance training and have developed information governance guidance for all staff to ensure staff are aware of their information governance roles and responsibilities. The Senior Information Risk Owner (SIRO) and the Caldicott Guardian have undertaken the training required for their roles.

There are processes in place for incident reporting and investigation of serious incidents. The CCG has not had any breaches of information security relating to the inappropriate release of patient identifiable data in 2015/16. The CCG uses the IG Toolkit Incident Reporting Tool to report IG Serious Incidents to the Health and Social Care Information Centre (HSCIC), Department of Health, ICO and other regulators.

The CCG submitted the Information Governance Toolkit to Department of Health in March 2016 and achieved Level 2 compliance.

Review of Economy, Efficiency & Effectiveness of the Use of Resources

The majority of expenditure of the CCG is managed through contracts with providers, based on NHS Standard Contract Terms. These contracts are drafted to ensure that value-for-money is at the core of service delivery to the patients of the area. During the year the Governing Body has worked hard to improve patient pathways for the delivery of care to our population. This work has been based on driving improved care at the same or lower cost.

During the year the CCG delivered QIPP savings of £4.21m. Value-for-money has been reviewed by the Governance and Risk Committee of the CCG which has looked in detail at specific areas of service delivery. In addition, our external auditors have reviewed value-for-money and reported on this within the financial statements. Internal Audit has also carried out work which has allowed the CCG to further improve economy, efficiency and effectiveness.

Review of the Effectiveness of Governance, Risk Management & Internal Control

As Accountable Officer I have responsibility for reviewing the effectiveness of the system of internal control within the Clinical Commissioning Group, including our hosting arrangements.

Capacity to Handle Risk

Risk awareness is the responsibility of all members of the Governing Body and of all staff, particularly the senior team. The Risk Management Policy sets out the responsibilities for managing risk. To ensure that all staff and Governing Body Members are aware of how to manage risk, a workshop is scheduled each year to provide training on the risk register.

My review of the effectiveness of the system of internal control is informed by the work of the internal auditors, who have provided significant assurance that the governance and financial controls are effective. My review is also informed by comments made by the external auditors in their management letter and other reports.

I am also informed by the Governing Body, the Executive Team and Clinical Leads within the CCG who have responsibility for the development and maintenance of risk management and the internal control framework. I have drawn on performance information available to me, which is also reviewed by the Quality and Operational Leadership Team on a monthly basis. I am also informed by the Governance and Risk Committee whose members provide rigorous challenge to the way in which the CCG conducts its business.

During the year, the internal auditors completed 6 audits at Thanet level, with another two still in fieldwork. These audits covered the following areas and each received the described level of audit opinion:

- CCG's Assurance Framework and the Risk Management process – reasonable assurance
- Information Governance Toolkit – reasonable assurance
- Critical financial systems including East Kent Financial Systems and East Kent

Payroll – substantial assurance

- Operation of Key Groups and Committees – Reasonable Assurance
- Performance Reporting to the Governing Body – Reasonable Assurance
- HR processes – limited assurance
- Better Care Fund Governance and Readiness – in fieldwork
- Provider Contract Management: Continuing Healthcare – Reasonable Assurance

Following completion of the planned audit work for the financial year for the Clinical Commissioning Group, the Head of Internal Audit has issued an independent and objective opinion on the adequacy and effectiveness of the Clinical Commissioning Group's system of risk management, governance and internal control.

The overall opinion of the Head of Internal Audit for TIAA Ltd is that: "*I am satisfied that sufficient internal audit work has been undertaken to allow me to draw a reasonable conclusion as to the adequacy and effectiveness of NHS Thanet CCG's internal control processes. In my opinion, NHS Thanet CCG has adequate and effective management, internal control processes to manage the achievement of its objectives.*"

The Head of Internal Audit considered the Local Counter Fraud Specialist reports throughout the year and there are no significant issues to take into account in preparing his Opinion.

Data Quality

The CCG has a contract with SECSU to validate the performance data it uses in its performance reports. The CCG's Quality and Performance teams are working together to review the IQPR to develop it into a more effective document. The intention is to:

- Strengthen the quality of the detailed information.
- Achieve better integration of project, finance and medicines management information.
- Achieve integration with new reporting requirements for locality clusters/hubs.
- Provide improved analysis and triangulation of the data.

- Provide better focus to the Membership Body and Governing Body on key issues, with particular emphasis on decisions that may need to be taken.
- Introduce a more concise report for Governing Body.

By reducing the volume of data reported to the Governing Body it will provide opportunities to link Governing Body performance reporting to the delivery of strategic objectives, organisational and operational plans and projects designed to improve patient outcomes. This will enhance current governance systems and provide the Governing Body with more meaningful information with which to direct the business of the CCG as it would be based on quality as well as quantity.

The Project Delivery Dashboards and the (planned) Delivery Report will be used to support the revised process.

Data Security

As I reported above, there have been no data security breaches at Thanet CCG and no reports made to the Information Commissioner's Office during the year.

Business Critical Models

The CCG has in hand a number of key projects which would fall under the heading of "business critical models" in accordance with the McPherson report, including development of strategies and policies (for example, for children and mental health services), projects such as the implementation of the Integrated Care Organisation model and development of the East Kent Strategy which relies on robust modelling of capacity. The CCG has put in place Quality Assurance (QA) arrangements which comply with the McPherson report to monitor these developments to ensure proper control. These include having a Senior Responsible Owner (SRO) who oversees each main project and signs it off; external peer review; use of internal audit to check progress; scrutiny by project boards and by independent members of the Governance and Risk Committee; and gateway reviews where appropriate. The CCG uses checklists such as Equality Impact Assessments and a programme dashboard to monitor progress. The programme SRO is content that the QA process is compliant and appropriate, risks are understood, and the use of the outputs are appropriate.

Discharge of Statutory Functions

The CCG has a number of statutory duties under the NHS Act 2006 as amended – sections 14Z15 (2)(a) and (b) -- which it must discharge. These include

- A requirement to improve services: we have done this through setting the priorities in our strategy, through our commissioning contracts and through monitoring performance against targets (page 23)
- A requirement to reduce inequalities: in our strategy we have prioritised those issues which will improve the health outcomes of the most vulnerable in Thanet (page 10)
- A requirement to involve the public and consult on proposed changes to service delivery: we have done this through our public engagement activities, a report of which is on (page 29).
- A requirement to contribute to the joint Health and Wellbeing Strategy – we have worked with the Kent Health and Wellbeing Board and the local Thanet Health and Wellbeing Board to help achieve this (see page 17) .

As the Accountable Officer, I certify that the CCG has complied with the statutory duties laid down by the NHS Act 2006 (as amended by the Health and Social Care Act 2012).

During establishment, the arrangements put in place by the CCG and explained within the *Corporate Governance Framework* were developed with extensive expert external legal input, to ensure compliance with the all relevant legislation. That legal advice also informed the matters reserved for Membership Body and Governing Body decision and the scheme of delegation.

In light of the Harris Review, the Clinical Commissioning Group has reviewed all of the statutory duties and powers conferred on it by the National Health Service Act 2006 (as amended) and other associated legislation and regulations. As a result, I can confirm that the Clinical Commissioning Group is clear about the legislative requirements associated with each of the statutory functions for which it is responsible, including any restrictions on delegation of those functions.

Responsibility for each duty and power has been clearly allocated to a lead staff member. Leaders of the CCG's teams have confirmed that their structures provide the necessary capability and capacity to undertake all of the Clinical Commissioning Group's statutory duties.

Conclusion

No significant control issues have been identified

Hazel Carpenter
Accounting Officer
25 May 2016

Biographies

NHS Thanet CCG Governing Body

Dr Tony Martin, NHS Thanet CCG Clinical Chair

Dr Tony Martin has been a GP at Bethesda Medical Centre, Cliftonville, Margate for over 25 years. He is responsible for the governing body's development and has a passionate belief in helping Thanet people to improve their health. Tony believes in providing joined-up care, involving a multi-agency approach and feels that medicine is about more than prescribing. For Tony, support with self-care and heath advice is essential. He studied medicine at Leicester University and runs a minor operations clinic locally.

Dr Mark Elliott, GP Member

Mark has been a GP at Minster Surgery, near Ramsgate, since 1999. He is a GP member of Thanet CCG's governing body and elected member and chair of the local GP out-of-hours service. Mark is a GP with special interests in dermatology and minor surgery. He runs a minor surgery clinic and is about to restart a Cryotherapy service. He studied medicine in Liverpool and is a member of the British Medical Association (BMA).

Dr Sabin Kamal GP Member (from Dec 2015)

Dr Kamal been working as GP Partner at Summerhill surgery in Ramsgate since 2012. She qualified as a GP in 2007 after finishing GP training in Kent. She is a member of the Royal

College of General Practitioners, British Medical Association and a clinical supervisor for FY2 at Kent Sussex and Surrey Deanery. She is an LMC representative for the Thanet area and since becoming a partner at the surgery three years ago, she has tried to get actively involved in the CCG at a locality level, attending and contributing to meetings, using guidance and best available evidence to shape our service.

Sabin has a strong belief in patients being at the centre of the decision-making process and the strength of integrated care, involving secondary care, the community and voluntary sector and other organisations.

Dr Adem Akyol GP member

Dr Akyol has been a GP at Newington Road Surgery, Ramsgate, since 2005 and is a member of the CCG's governing body. He has a special interest in urgent care, minor surgery, out-of-hours service and ultrasound. Adem studied at Germany's University of Dusseldorf and started practicing in 1994 in Bangor, Wales. During his career he has worked in Germany, The Netherlands, Denmark, Norway, Ghana and Australia. Adem is a member of the British Medical Association and is married with two children. He moved to Kent in 2004.

Hazel Carpenter, Accountable Officer

Hazel is NHS Thanet CCG's Accountable Officer, and also the Accountable Officer for NHS South Kent Coast CCG. She has worked in NHS commissioning organisations across Surrey and Kent since 2002 and has led the development of commissioning organisations, working as Director of Workforce and Organisation Development within NHS Eastern and Coastal Kent Primary Care Trust. In 2011, she was appointed Director of Commissioning Development for NHS Kent and Medway Primary Care Trust. Hazel has supported clinical commissioning development both working with the GP Deans office and through various clinical leadership programmes.

She studied at Leicester University, Kingston University and the University of Manchester. She has been a GP supervisor for the Kent Surrey and Sussex Deanery and is a member of the Chartered Institute of Personnel and Development.

Dr Tariq Rahman, GP member (until Nov 2015)

Dr Rahman has been a GP at Cecil Square Surgery, Margate, since 1990. Tariq is joint lead for urgent and long-term care for the CCG and is also responsible for outreach clinic negotiations with East Kent Hospitals University NHS Foundation Trust (EKHUFT). He studied in Dhaka, Bangladesh, and started practicing as a GP in 1989. Tariq moved to Kent in 1983.

Dr John Neden, GP member

Dr John Neden has been a GP at Eastcliff Practice, Ramsgate, for 25 years and is the CCG's clinical lead for long-term conditions and planned care. John is interested in primary care, with a particular interest in care for patients with advanced disease.

John studied medicine at Cambridge University and King's College, London, and qualified as a GP in 1984. During his career he has worked for Pilgrims Hospices and worked as a Macmillan GP facilitator, a GP with a special interest in chronic pain management and a GP trainer.

Jonathan Bates, Chief Finance Officer

Jonathan is Chief Finance Officer for NHS Thanet CCG and NHS South Kent Coast.
He is a chartered accountant who started his career in the City, auditing large firms and City institutions. After a spell working freelance for the Audit Commission he joined the London Borough of Bromley with responsibility for the schools and colleges finances.
Jonathan joined the NHS in 1995 as Deputy Director of Finance at Maidstone Hospital, and in 2002 he became Director of Finance for Ashford PCT. After a short period as Director of Finance for Swale PCT he joined Medway PCT as Director of Finance and Assurance. In 2012 he was appointed to the Kent and Medway PCT Cluster Board.
Jonathan is the author of three books on public sector finance and management.

Clive Hart, Lay member with responsibility for patient and public engagement

During more than a decade as a local elected representative Clive went on to become both leader of the opposition and eventually the leader at Thanet District Council, each for periods of two-and-a-half years.
He is a firm believer in lifelong learning and in addition to his City and Guilds electrical craft qualifications, Clive also qualified as a Health and Safety Adviser with NEBOSH while working in the electricity supply industry. He later studied and attained distinction at degree level through a course in Voluntary Studies with the CAB, a BTEC Management Studies qualification whilst working at Thanet College and went on to successfully graduate from the Improvement & Development Agency Leadership Academy while a member at Kent County Council.
Clive stood down from his role as a councillor in 2015 to take on the Lay Member PPE role here at NHS Thanet CCG.

Professor Devaka Fernando, Secondary Care Doctor

Sri Lanka-born consultant endocrinologist Professor Devaka Fernando, 56, is NHS Thanet CCG's independent member for secondary (hospital) care.

After completing his postgraduate training in endocrinology (hormones) in Manchester he returned to Sri Lanka from 1990 to1998 to help set up a new medical school and became honorary foundation professor of medicine and a fellow of the College of General Practitioners of Sri Lanka.

He has been a consultant on projects run by the World Bank to advise Ministries of Health on long-term conditions and integrated health care in Egypt, the Maldives, India and Sri Lanka and has worked with the World Diabetes Foundation and the Welcome Trust.

David Lewis, Lay member governance and audit chair

David is NHS Thanet CCG's lay member for governance and is also the audit chair. He is also the CCG's vice chair.

David has been involved in commissioning for a number of years, as a non-executive director and audit chair at NHS Kent and Medway primary care trust and NHS Surrey primary care trust.

He was previously Finance Director at Kent County Council (KCC) for ten years, and Treasurer of Kent Police Authority, where his achievements included negotiating the financial agreement for the Kings Hill Business Park Development and the Medway Tunnel. He studied economics with law at the University of Sheffield and gained a master's degree in public finance, specialising in environmental economics, at the University of York.

Born in Gillingham, David moved to Staffordshire aged five and returned to Kent in 1986. He is a youth football referee and spends some of his spare time watching Gillingham play football.

Sharon Gardner-Blatch, Chief Nursing Officer

Sharon has nursed in the NHS for over 25 years within London and the South East of England. She has experience of nursing in hospitals including intensive care and out of hospital care. She is passionate about and committed to supporting the total care of patients in partnership with their families / carers. Over the last ten years, Sharon has been committed to driving up standards to achieve high quality patient care which protects patients from avoidable harm. Since moving into commissioning she has been involved in holding NHS organisations to account for their quality of service delivery, service standards and safeguarding of patients.

Dr Jihad Malasi (from 1 Jan 2016)

Canterbury-born Dr Malasi practises from Dashwood Medical Practice, and started his medical career at Margate's QEQM hospital.

Dr Malasi has a particular interest in mental health, and has extensive experience in the field of psychiatric intensive care.

With a keen interest in martial arts and climbing, Dr Malasi also has a background in emergency sports medicine, and has trained with rugby doctors at Twickenham. Married with three children, Dr Malasi is keen to use his knowledge and skill to benefit the work of the CCG.

He said: “Thanet is an exciting area that’s blessed with wonderful assets such as beautiful coastline and cultural scene. But it’s also an area that has pockets of significant deprivation, and this is reflected in life expectancy gaps, child poverty and above-average rates of preventable disease.

“The CCG is committed to tackling these matters, ensuring that the people of Thanet are empowered to lead lives that are as healthy as possible. It’s a great privilege for me to join the CCG governing body and play an active part in shaping the area’s healthcare.”

Senior Staff Members

Ailsa Ogilvie, Chief Operating Officer

Prior to joining the CCG in March 2014 Ailsa worked within the voluntary sector where she held board level positions in Marketing and Operations for over 25 years. She has a track record of leading change in national organisations such as Scope and Age Concern England and has welcomed the opportunity to join Thanet CCG at this exciting time of transformation.

Sue Martin, Company Secretary

Sue Martin joined the CCG as Head of Governance in January 2014. She has worked in the public and not-for-profit sector throughout her career and her most recent position being with the Care Quality Commission (CQC). Sue is a chartered secretary and has many years’ experience of supporting Boards.

REMUNERATION AND STAFF REPORT

Remuneration Report

The Accountable Officer's view is that Senior Managers are those who are voting members of the Membership Body and Governing Body. Information about their remuneration is set out below. The CCG uses the NHS VSM pay scale for remuneration of board level staff. The Chief Nursing Officer is the only exception and remunerated using NHS Agenda for Change pay scale.

The CCG spent £90,430 on consultancy in 2015-16 (2014/15 £224,540).

Salaries and Allowances (Subject to Audit)

The accountable officer, chief finance officer and chief nursing officer work across both South Kent Coast CCG and Thanet CCG. Their salaries are split between the CCGs on a 50:50 split and both net and gross costs are shown below.

Net Cost to Thanet CCG 2015-16						
Name and Title	**(a) Salary (bands of £5,000)**	**(b) Expense payments (taxable) (band of £100)**	**(c) Performance Pay and Bonus Payments (bands of £5,000)**	**(d) Long term performance pay and bonuses (bands of £5,000)**	**(e) All Pension Related Benefits (bands of £2,500)**	**(f) Total (bands of £5,000)**
	£'000	**£'00**	**£'000**	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	55-60	0-1	0	0	7.5-10	60-65
Jonathan Bates - Chief Finance Officer	50-55	0	0	0	2.5-5	55-60
Sharon Gardner-Blatch - Chief Nursing Officer	40-45	0-1	0	0	10-12.5	50-55
Dr Tony Martin - Clinical Chair	65-70	0	0	0	0	65-70
Professor Devaka Fernando - Secondary Care Doctor	40-45	0	0	0	0	40-45
Dr John Neden - Governing Body Elected GP Member	60-65	0	0	0	15-17.5	80-85
Dr Mark Elliott - Governing Body Elected GP Member	30-35	0-1	0	0	0	30-35

Dr Adem Akyol - Governing Body Elected GP Member	15-20	0	0	0	5-7.5	20-25
Dr Tariq Rahman - Governing Body Elected GP Member (01/04/2015 - 30/11/2015)	5-10	0	0	0	0	5-10
Dr Jihad Malasi - Governing Body Elected GP Member (01/01/2016 - 31/03/2016)	5-10	0	0	0	20-22.5	25-30
Dr Sabin Kamal - Governing Body Elected GP Member (01/12/2015 - 31/03/2016)	5-10	0	0	0	25-27.5	30-35
David Lewis - Lay Member (Governance)	10-15	4-5	0	0	0	10-15
Clive Hart - Lay Member (Patient and Public Engagement)	10-15	0.1	0	0	0	10-15

Gross Cost to Thanet CCG 2015-16						
Name and Title	**(a) Salary (bands of £5,000)**	**(b) Expense payments (taxable) (band of £100)**	**(c) Performance Pay and Bonus Payments (bands of £5,000)**	**(d) Long term performance pay and bonuses (bands of £5,000)**	**(e) All Pension Related Benefits (bands of £2,500)**	**(f) Total (bands of £5,000)**
	£'000	**£'00**	**£'000**	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	110-115	1-2	0	0	15-17.5	125-130
Jonathan Bates - Chief Finance Officer	100-105	0	0	0	7.5-10	115-120
Sharon Gardner-Blatch - Chief Nursing Officer	80-85	0-1	0	0	22.5-25	105-110

Please note that the figures shown in 'All Pension Related Benefits' are an estimate of the increase in pension should it be paid over 20 years of life from retirement if there is no benefit then a zero is shown.

Salaries and Allowances: Comparison With Previous Year 2014/15

Net Cost to Thanet CCG 2014-15					
Name and Title	**Salary (bands of £5,000)**	**Expense payments (taxable) (band of £100)**	**Performance Pay and Bonus Payments (bands of £5,000)**	**All Pension Related Benefits (bands of £2,500)**	**Total (bands of £5,000)**
	£'000	**£'00**	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	45-50	1-2	0	0	40-45
Jonathan Bates - Chief Finance Officer	40-45	0	0	0-2.5	40-45
Sharon Gardner-Blatch - Chief Nursing Officer	30-35	1-2	0	20-22.5	50-55
Dr Tony Martin - Clinical Chair	60-65	0	0	60-62.5	125-130
Professor Devaka Fernando - Secondary Care Doctor	40-45	0-1	0	0	40-45
Dr John Neden - Governing Body Elected GP Member	60-65	0	0	0	60-65
Dr Mark Elliott - Governing Body Elected GP Member	30-35	0	0	0	30-35
Dr Andrew Walton - Governing Body Elected GP Member	35-40	0	0	52.5-55	90-95
Dr Adem Akyol - Governing Body Elected GP Member	15-20	0	0	35-37.5	50-55
Dr Tariq Rahman - Governing Body Elected GP Member	15-20	0	0	0	15-20
David Lewis - Lay Member (Governance)	10-15	0-1	0	0	10-15
Dominic Carter - Lay Member (Patient and Public Engagement)	10-15	0	0	0	10-15

Dr Andrew Walton left the CCG on 31/03/2015

Gross Cost of posts shared with SKC CCG 2014-15					
Name and Title	**Salary (bands of £5,000)**	**Expense payments (taxable) (band of £100)**	**Performance Pay and Bonus Payments (bands of £5,000)**	**All Pension Related Benefits (bands of £2,500)**	**Total (bands of £5,000)**
	£'000	**£'00**	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	110-115	3-4	0	0	110-115
Jonathan Bates - Chief Finance Officer	100-105	0	0	0-2.5	100-105
Sharon Gardner-Blatch - Chief Nursing Officer	75-80	3-4	0	50-52.5	130-135

Pay Multiples

Reporting bodies are required to disclose the relationship between the remuneration of the highest-paid director/Member in their organisation and the median remuneration of the organisation's workforce.

The banded remuneration of the highest paid director/Member in NHS Thanet CCG in the financial year 2015-16 was £112,500 (2014-15, £112,500). This was 2.44 times (2014-15, 2.15) the median remuneration of the workforce, which was £46,164 (2014-15, £52,235).

In 2015-16, 0 (2014-15, 0) employees received remuneration in excess of the highest-paid director/member. Remuneration ranged from £16,633 to £112,500 (2014-15 £16,633 - £112,500)

Total remuneration includes salary, non-consolidated performance related pay, benefits-in-kind, but not severance payments. It does not include employer pension contributions and the cash equivalent transfer value of pensions.

Band of Highest Paid Director's Total Remuneration (£'000)	110-115
Remuneration Median Total	46,164
Remuneration Ratio	2.44

The change from 2.15 to 2.44 is due to the CCG bring some functions, which were previously supplied by South East Commissioning Support Unit, in house. As a result the average staff salary has decreased.

Pension Benefits

Pension Benefits				
Name and Title	**(a) Real increase in pension at pension age**	**(b) Real increase in pension lump sum at pension age**	**(c) Total accrued pension at pensionage at 31 March 2016**	**(d) Lump sum at pension age related to accrued pension at 31 March 2016**
	(bands of £2,500)	**(bands of £2,500)**	**(bands of £5,000)**	**(bands of £5,000)**
	£'000	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	0-2.5	0	35-40	100-105
Jonathan Bates - Chief Finance Officer	0-2.5	2.5-5	25-30	80-85
Sharon Gardner-Blatch - Chief Nursing Officer	0-2.5	0-2.5	20-25	55-60
John Neden - GP Member	0-2.5	2.5-5	15-20	45-50
Adem Akyol - GP Member	0-2.5	0-2.5	5-10	15-20
Jihad Malasi - GP Member	0-2.5	2.5-5	0-5	0-5
Sabin Kamal	0-2.5	2.5-5	0-5	0-5

	(e) Cash Equivalent Transfer Value at 1 April 2015 with Inflation added	**(f) Real Increase in Cash Equivalent Transfer Value**	**(g) Cash Equivalent Transfer Value at 31 March 2016**	**(h) Employer's contribution to partnership pension**
	£'000	**£'000**	**£'000**	**£'000**
Hazel Carpenter - Accountable Officer	550	19	569	N/A
Jonathan Bates - Chief Finance Officer	550	25	575	N/A
Sharon Gardner-Blatch - Chief Nursing Officer	308	21	329	N/A
John Neden - GP Member	298	25	323	N/A
Adem Akyol - GP Member	103	5	108	N/A

Jihad Malasi - GP Member	0	13	13	N/A
Sabin Kamal	0	18	18	N/A

Certain Members do not receive pensionable remuneration therefore there will be no entries in respect of pensions for those Members.

Greenbury information for Dr Malasi and Dr Jihad was not received so their pension benefits have been estimated based on other members' benefits.

Dr Tony Martin left the pension scheme on 30/01/2015.

Dr Andrew Walton left the governing body 31/03/2015.

On 16 March 2016, the Chancellor of the Exchequer announced a change in the Superannuation Contributions Adjusted for Past Experience (SCAPE) discount rate from 3.0% to 2.8%. This rate affects the calculation of CETV figures in this report.

Due to the lead time required to perform calculations and prepare annual reports, the CETV figures quoted in this report for members of the NHS Pension scheme are based on the previous discount rate and have not been recalculated.

Pension Benefits: Comparison With Previous Year 2014/15

Name and Title	(a) Real increase in pension at age 60	(b) Real increase in pension lump sum at age 60	(c) Total accrued pension at age 60 at 31 March 2015	(d) Lump sum at age 60 related to accrued pension at 31 March 2015
	(bands of £2,500)	(bands of £2,500)	(bands of £5,000)	(bands of £5,000)
	£'000	£'000	£'000	£'000
Hazel Carpenter - Accountable Officer	0-2.5	0-2.5	30-35	100-105
Jonathan Bates - Chief Finance Officer[1]	0-2.5	0-2.5	25-30	75-80
Sharon Gardner-Blatch - Chief Nursing Officer	2.5-5	7.5-10	15-20	55-60
Tony Martin - Clinical Chair	2.5-5	7.5-10	5-10	20-25

Andrew Walton - GP Member	2.5-5	7.5-10	5-10	25-30
Adem Akyol - GP Member	0-2.5	5-7.5	5-10	15-20
John Neden - GP Member	0-2.5	0-2.5	10-15	40-45

	(e) Cash Equivalent Transfer Value at 1 April 2014 with Inflation added	(f) Real Increase in Cash Equivalent Transfer Value	(g) Cash Equivalent Transfer Value at 31 March 2015 with Inflation added	(h) Employer's contribution to partnership pension
Hazel Carpenter - Accountable Officer	521	23	544	N/A
Jonathan Bates - Chief Finance Officer[1]	515	28	543	N/A
Sharon Gardner-Blatch - Chief Nursing Officer	254	50	305	N/A
Tony Martin - Clinical Chair	102	67	169	N/A
Andrew Walton - GP Member	133	50	184	N/A
Adem Akyol - GP Member	72	30	102	N/A
John Neden - GP Member	285	8	294	N/A

Our staff

The total Thanet CCG Staff employed through ESR was 41 as of the 31 March 2016, and a further 12 employed as Governing Body members and/or Clinical Leads. The FTE is 38.8.

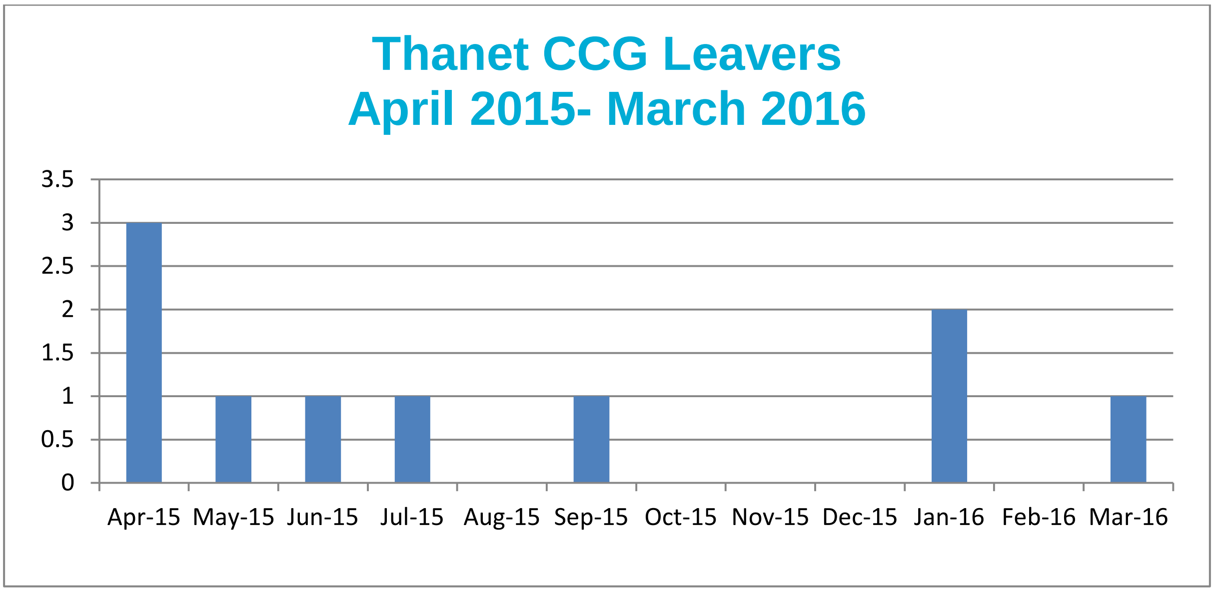
Leavers April 2015 – 2016

A number of members of staff left the CCG during this period for the following reasons:

- 8 Voluntary resignation – (not known/promotion/health/work life balance/other

- 1 Retirement
- 1 End of fixed term contract

Calculating an average of 41 members of staff (excluding GPs) over the period, staff turnover is 24.4%. The national UK average is around 15% with an expected rise of 3% over the next 2 years due to an improving economy.

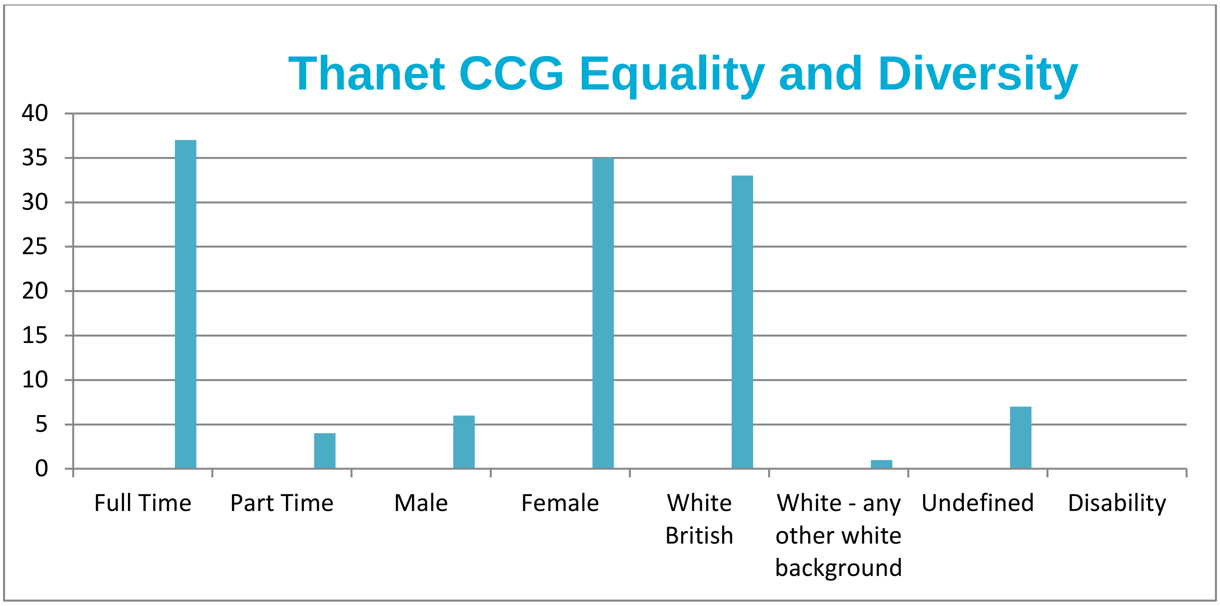


Cultural Diversity

The graph below gives a screen shot of the CCG's diverse workforce and shows that of the staff employed by Thanet CCG, 14.6% are male and 85.3% female.
The number of staff currently working part time has decreased from last year to 9.75%.

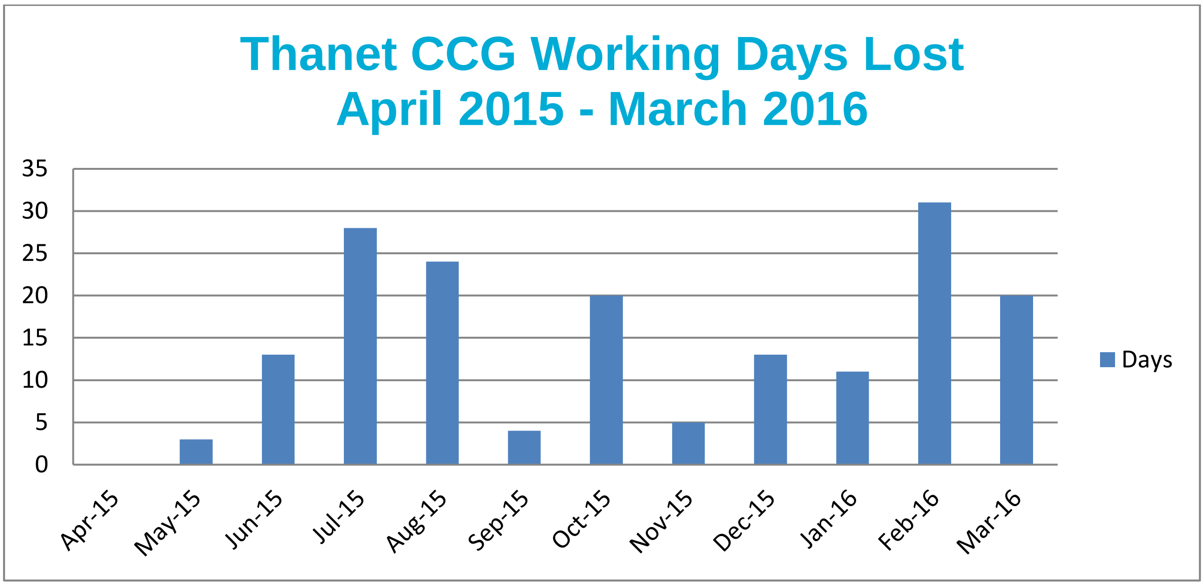
In terms of ethnicity, 80.49% of staff have declared themselves as white British however, a high number of ethnicities are recorded as undefined (17.07%). This is due to the information not being fully completed on starter forms.

No employees have a declared disability.



Sickness Absence

Sickness at Thanet CCG during the period of April 2015 – March 2016 averages at 14.3 days per month from a total availability of 843 working days per month, giving a 1.73% sickness rate. The national average NHS sickness absence rate fluctuates between 4% -4.5%. CCG's specifically, fluctuated between 2% - 3% over the past two years.



Equality Disclosures

The CCG has a Disability Policy which sets out its intentions to ensure that people with disabilities are given full and fair consideration when they apply for employment and that staff with a disability are supported to ensure they are able to be effective as employees. The CCG is committed to achieving its equality objectives and is reviewing the Equality Diversity Standard 2 to identify areas for improvement

Employee Consultation

- The CCG continues to run a joint staff engagement forum with NHS South Kent Coast CCG. The meetings are held on a monthly basis and are chaired by the Company Secretary for both CCGs. In 2015/16 the staff forum ratified policies including sustainability and all HR policies as well as continuing to develop a staff handbook.
- The staff forum also led the annual staff survey, to keep abreast of staff issues. The questions included whether staff feel appropriately supported by their line managers, the training and development offered to them and how visible and accessible the Governing Body members are to staff on a daily basis. The results will be collated and fed back at the staff development days.
- A weekly team meeting is held every Friday morning which gives the Executive Team the opportunity to brief staff on any important matters concerning the business and operations and to recap the previous week's main issues.
- In addition the staff are invited to development days to learn more about each other and how to get the best out of colleagues. How these staff development days are facilitated also formed part of the staff survey as the CCG aims to ensure staff get the most out of them that they can.
- An electronic bulletin is sent to all CCG staff on a weekly basis. This provides a way for the CCG to communicate with the membership on any internal or external issues of relevance to the staff and CCG.

Exit Packages and Severance Payments

There were no exit packages or severance payments made by the CCG in 2015/16.

Off Payroll Engagements

There were no off payroll engagement of staff for more than £220 per day and lasting more than 6 months during 2015/16.

Performance Related Pay

The CCG has no performance related pay policy in operation.

Payments for Loss of Office

There were no payments made for loss of office in 2015/16.

Payments to Past Senior Managers

No payments have been made

INDEPENDENT AUDITOR'S REPORT TO THE MEMBERS OF

NHS THANET CLINICAL COMMISSIONING GROUP

INDEPENDENT AUDITOR'S REPORT TO THE MEMBERS OF THE GOVERNING BODY OF NHS THANET CLINICAL COMMISSIONING GROUP

We have audited the financial statements of NHS Thanet Clinical Commissioning Group (CCG) for the year ended 31 March 2016 under the Local Audit and Accountability Act 2014 (the "Act"). The financial statements comprise the Statement of Comprehensive Net Expenditure, the Statement of Financial Position, the Statement of Changes in Taxpayers' Equity, the Statement of Cash Flows and the related notes. The financial reporting framework that has been applied in their preparation is applicable law and International Financial Reporting Standards (IFRSs) as adopted by the European Union, and as interpreted and adapted by the 2015/16 Government Financial Reporting Manual (the 2015/16 FReM) as contained in the Department of Health Group Manual for Accounts 2015/16 (the 2015/16 MfA) and the Accounts Direction issued by the NHS Commissioning Board with the approval of the Secretary of State as relevant to the National Health Service in England (the Accounts Direction).

We have also audited the information in the Remuneration and Staff Report that is subject to audit, being:

• the table of salaries and allowances of senior managers and related narrative notes on pages 76 to 79

• the table of pension benefits of senior managers and related narrative notes on pages 80 to 82

• disclosure of payments for loss of office on page 86

• disclosure of payments to past senior managers on page 86

• the table of exit packages and related narrative notes on page 86

• the analysis of staff numbers and related narrative notes on pages 82 to 84; and

• the tables of pay multiples and related narrative notes on page 79 to 80.

This report is made solely to the members of the Governing Body of NHS Thanet Clinical Commissioning Group, as a body, in accordance with Part 5 of the Act and as set out in paragraph 43 of the Statement of Responsibilities of Auditors and Audited Bodies published by Public Sector Audit Appointments Limited. Our audit work has been undertaken so that we might state to the members of the Governing Body of the CCG those matters we are required to state to them in an auditor's report and for no other purpose. To the fullest extent permitted by law, we do not accept or assume responsibility to anyone other than the CCG and the members of the Governing Body of the CCG, as a body, for our audit work, for this report, or for the opinions we have formed.

Respective responsibilities of the Accountable Officer and auditor

As explained more fully in the Statement of Accountable Officer's Responsibilities, the Accountable Officer is responsible for the preparation of the financial statements and for being satisfied that they give a true and fair view and is also responsible for ensuring the regularity of expenditure and income. Our responsibility is to audit and express an opinion on the financial statements in accordance with applicable law and International Standards on Auditing (UK and Ireland). Those standards require us to comply with the Auditing Practices Board's Ethical Standards for Auditors. We are also responsible for giving an opinion on the regularity of expenditure and income in accordance with the Code of Audit Practice prepared by the Comptroller and Auditor General as required by the Act (the "Code of Audit Practice").

As explained in the Annual Governance Statement the Accountable Officer is responsible for the arrangements to secure economy, efficiency and effectiveness in the use of the CCG's resources. We are required under Section 21 (1)(c) of the Act to be satisfied that the CCG has made proper arrangements for securing economy, efficiency and effectiveness in its use of resources and to report our opinion as required by Section 21(4)(b) of the Act.

We are not required to consider, nor have we considered, whether all aspects of the CCG's arrangements for securing economy, efficiency and effectiveness in its use of resources are operating effectively.

Scope of the audit of the financial statements

An audit involves obtaining evidence about the amounts and disclosures in the financial statements sufficient to give reasonable assurance that the financial statements are free from material misstatement, whether caused by fraud or error. This includes an assessment of: whether the accounting policies are appropriate to the CCG's circumstances and have been consistently applied and adequately disclosed; the reasonableness of significant accounting estimates made by the Accountable Officer; and the overall presentation of the financial statements. In addition, we read all the financial and non-financial information in the Annual Report to identify material inconsistencies with the audited financial statements and to identify any information that is apparently materially incorrect based on, or materially inconsistent with, the knowledge acquired by us in the course of performing the audit. If we become aware of any apparent material misstatements or inconsistencies we consider the implications for our report.

In addition, we are required to obtain evidence sufficient to give reasonable assurance that the expenditure and income recorded in the financial statements have been applied to the purposes intended by Parliament and the financial transactions conform to the authorities which govern them.

Scope of the review of arrangements for securing economy, efficiency and effectiveness in the use of resources

We have undertaken our review in accordance with the Code of Audit Practice, having regard to the guidance on the specified criteria, issued by the Comptroller and Auditor General in November 2015, as to whether the CCG had proper arrangements to ensure it took properly informed decisions and deployed resources to achieve planned and sustainable outcomes for taxpayers and local people. The Comptroller and Auditor General determined these criteria as that necessary for us to consider under the Code of Audit Practice in satisfying ourselves whether the CCG put in place proper arrangements for securing economy, efficiency and effectiveness in its use of resources for the year ended 31 March 2016, and to report by exception where we are not satisfied.

We planned our work in accordance with the Code of Audit Practice. Based on our risk assessment, we undertook such work as we considered necessary to form a view on whether, in all significant respects, the CCG had put in place proper arrangements to secure economy, efficiency and effectiveness in its use of resources.

Opinion on financial statements

In our opinion the financial statements:

- give a true and fair view of the financial position of NHS Thanet Clinical Commissioning Group as at 31 March 2016 and of its expenditure and income for the year then ended; and
- have been prepared properly in accordance with IFRSs as adopted by the European Union, as interpreted and adapted by the 2015/16 FReM as contained in the 2015/16 MfA and the Accounts Direction.

Opinion on regularity

In our opinion, in all material respects the expenditure and income recorded in the financial statements have been applied to the purposes intended by Parliament and the financial transactions in the financial statements conform to the authorities which govern them.

Opinion on other matters

In our opinion:

- the parts of the Remuneration and Staff Report to be audited have been properly prepared in accordance with IFRSs as adopted by the European Union, as interpreted and adapted by the 2015/16 FReM as contained in the 2015/16 MfA and the Accounts Direction; and
- the other information published together with the audited financial statements in the annual report and accounts is consistent with the financial statements.

Matters on which we are required to report by exception

We are required to report to you if:

- in our opinion the governance statement does not comply with the guidance issued by the NHS Commissioning Board; or
- we refer a matter to the Secretary of State under section 30 of the Act because we have reason to believe that the CCG, or an officer of the CCG, is about to make, or has made, a decision which involves or would involve the body incurring unlawful expenditure, or is about to take, or has begun to take a course of action which, if followed to its conclusion, would be unlawful and likely to cause a loss or deficiency; or
- we issue a report in the public interest under section 24 of the Act; or
- we make a written recommendation to the CCG under section 24 of the Act; or
- we are not satisfied that the CCG has made proper arrangements for securing economy, efficiency and effectiveness in its use of its resources for the year ended 31 March 2016.

We have nothing to report in these respects.

Certificate

We certify that we have completed the audit of the accounts of NHS Thanet Clinical Commissioning Group in accordance with the requirements of the Act and the Code of Audit Practice.

Elizabeth Olive

for and on behalf of Grant Thornton UK LLP, Appointed Auditor

Grant Thornton UK LLP
Grant Thornton House
Melton Street
London
NW1 2EP

25 May 2016

THANET CLINICAL COMMISSIONING GROUP

ANNUAL ACCOUNTS

2015/16

NHS Thanet Clinical Commissioning Group - Annual Accounts 2015-16

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The Primary Statements:

Notes to the Accounts

Statement of Comprehensive Net Expenditure for the year ended 31-March-2016

	Note	2015-16 £000	2014-15 £000
Total Income and Expenditure			
Employee benefits	4.1.1	1,611	1,427
Operating Expenses	5	202,908	195,779
Other operating revenue	2	(458)	(585)
Net operating expenditure before interest		**204,061**	**196,621**
Other (gains)/losses		0	0
Finance costs		0	0
Net operating expenditure for the financial year		**204,061**	**196,621**
Net (gain)/loss on transfers by absorption		0	0
Total Net Expenditure for the year		**204,061**	**196,621**
Of which:			
Administration Income and Expenditure			
Employee benefits	4.1.1	1,327	1,276
Operating Expenses	5	1,817	2,279
Other operating revenue	2	(30)	(31)
Net administration costs before interest		**3,114**	**3,524**
Programme Income and Expenditure			
Employee benefits	4.1.1	284	151
Operating Expenses	5	201,091	193,500
Other operating revenue	2	(428)	(554)
Net programme expenditure before interest		**200,946**	**193,097**

Other Comprehensive Net Expenditure	**2015-16 £000**	2014-15 £000
Total comprehensive net expenditure for the year	**204,061**	**196,621**

The notes on pages 1 to 31 form part of this statement

Statement of Financial Position as at 31-March-2016

	Note	2015-16 £000	2014-15 £000
Non-current assets:			
Property, plant and equipment	8	118	15
Total non-current assets		118	15
Current assets:			
Trade and other receivables	9	2,348	1,441
Other current assets		0	0
Cash and cash equivalents	10	45	71
Total current assets		**2,393**	**1,512**
Total current assets		**2,393**	**1,512**
Total assets		**2,511**	**1,527**
Current liabilities			
Trade and other payables	11	(14,543)	(14,060)
Provisions	12	(65)	(262)
Total current liabilities		**(14,608)**	**(14,322)**
Non-Current Assets plus/less Net Current Assets/Liabilities		**(12,097)**	**(12,795)**
Non-current liabilities			
Trade and other payables		0	0
Provisions		0	0
Total non-current liabilities		**0**	0
Assets less Liabilities		**(12,097)**	**(12,795)**
Financed by Taxpayers' Equity			
General fund		(12,097)	(12,795)
Total taxpayers' equity:		**(12,097)**	**(12,795)**

The notes on pages 1 to 31 form part of this statement

The financial statements on pages 1 to 31 were approved by the Governance and Risk Committee on 23 May 2016 and signed on its behalf by Hazel Carpenter, Accountable Officer

Chief Accountable Officer
Hazel Carpenter

Statement of Changes In Taxpayers Equity for the year ended 31-March-2016

	General fund £000	Total reserves £000
Changes in taxpayers' equity for 2015-16		
Balance at 1 April 2015	(12,795)	(12,795)
Adjusted NHS Clinical Commissioning Group balance at 1 April 2015	**(12,795)**	**(12,795)**
Changes in NHS Clinical Commissioning Group taxpayers' equity for 2015-16		
Net operating expenditure for the financial year	(204,061)	(204,061)
Net Recognised NHS Clinical Commissioning Group Expenditure for the Financial Year	**(204,061)**	**(204,061)**
Net funding	204,758	204,758
Balance at 31 March 2016	**(12,097)**	**(12,097)**

	General fund £000	Total reserves £000
Changes in taxpayers' equity for 2014-15		
Balance at 1 April 2014	(15,213)	**(15,213)**
Adjusted NHS Clinical Commissioning Group balance at 1 April 2014	**(15,213)**	**(15,213)**
Changes in NHS Commissioning Board taxpayers' equity for 2014-15		
Net operating costs for the financial year	(196,621)	(196,621)
Net Recognised NHS Commissioning Board Expenditure for the Financial Year	**(196,621)**	**(196,621)**
Net funding	199,039	199,039
Balance at 31 March 2015	**(12,795)**	**(12,795)**

The notes on pages 1 to 31 form part of this statement

Statement of Cash Flows for the year ended 31-March-2016

	Note	2015-16 £000	2014-15 £000
Cash Flows from Operating Activities			
Net operating expenditure for the financial year		(204,061)	(196,621)
Depreciation and amortisation	8	5	5
(Increase)/decrease in trade & other receivables	9	(906)	300
Increase/(decrease) in trade & other payables	11	484	(2,929)
Provisions utilised	12	(83)	0
Increase/(decrease) in provisions	12	(115)	262
Net Cash Inflow (Outflow) from Operating Activities		**(204,676)**	**(198,983)**
Cash Flows from Investing Activities			
(Payments) for property, plant and equipment	8	(108)	0
Net Cash Inflow (Outflow) from Investing Activities		**(108)**	0
Net Cash Inflow (Outflow) before Financing		**(204,784)**	**(198,983)**
Cash Flows from Financing Activities			
Grant in Aid Funding Received		204,758	199,039
Net Cash Inflow (Outflow) from Financing Activities		**204,758**	**199,039**
Net Increase (Decrease) in Cash & Cash Equivalents	10	**(26)**	**56**
Cash & Cash Equivalents at the Beginning of the Financial Year		**71**	15
Cash & Cash Equivalents (including bank overdrafts) at the End of the Financial Year		**45**	**71**

The notes on pages 1 to 31 form part of this statement

Notes to the financial statements

1.0 Accounting Policies

NHS England has directed that the financial statements of clinical commissioning groups shall meet the accounting requirements of the *Manual for Accounts* issued by the Department of Health. Consequently, the following financial statements have been prepared in accordance with the *Manual for Accounts 2015-16* issued by the Department of Health. The accounting policies contained in the *Manual for Accounts* follow International Financial Reporting Standards to the extent that they are meaningful and appropriate to clinical commissioning groups, as determined by HM Treasury, which is advised by the Financial Reporting Advisory Board. Where the *Manual for Accounts* permits a choice of accounting policy, the accounting policy which is judged to be most appropriate to the particular circumstances of the clinical commissioning group for the purpose of giving a true and fair view has been selected. The particular policies adopted by the clinical commissioning group are described below. They have been applied consistently in dealing with items considered material in relation to the accounts.

1.1 Going Concern

These accounts have been prepared on the going concern basis.

The CCG operated In 2015/16 and has agreed a budget plan for 2016/17 within its annual statutory expenditure limit. The CCG has reviewed affordability of services going forward and is satisfied that statutory financial balance is achieveable.

Public sector bodies are assumed to be going concerns where the continuation of the provision of a service in the future is anticipated, as evidenced by inclusion of financial provision for that service in published documents.

Where a clinical commissioning group ceases to exist, it considers whether or not its services will continue to be provided (using the same assets, by another public sector entity) in determining whether to use the concept of going concern for the final set of Financial Statements. If services will continue to be provided the financial statements are prepared on the going concern basis.

1.2 Accounting Convention

These accounts have been prepared under the historical cost convention modified to account for the revaluation of property, plant and equipment, intangible assets, inventories and certain financial assets and financial liabilities.

1.3 Acquisitions & Discontinued Operations

Activities are considered to be ‘acquired’ only if they are taken on from outside the public sector. Activities are considered to be ‘discontinued’ only if they cease entirely. They are not considered to be ‘discontinued’ if they transfer from one public sector body to another.

1.4 Movement of Assets within the Department of Health Group

Transfers as part of reorganisation fall to be accounted for by use of absorption accounting in line with the Government Financial Reporting Manual, issued by HM Treasury. The Government Financial Reporting Manual does not require retrospective adoption, so prior year transactions (which have been accounted for under merger accounting) have not been restated. Absorption accounting requires that entities account for their transactions in the period in which they took place, with no restatement of performance required when functions transfer within the public sector. Where assets and liabilities transfer, the gain or loss resulting is recognised in the Statement of Comprehensive Net Expenditure, and is disclosed separately from operating costs.

Other transfers of assets and liabilities within the Department of Health Group are accounted for in line with IAS 20 and similarly give rise to income and expenditure entries.

1.5 Pooled Budgets

Where the clinical commissioning group has entered into a pooled budget arrangement under Section 75 of the National Health Service Act 2006 the clinical commissioning group accounts for its share of the assets, liabilities, income and expenditure arising from the activities of the pooled budget, identified in accordance with the pooled budget agreement.
If the clinical commissioning group is in a "jointly controlled operation", the clinical commissioning group recognises:

* The assets the clinical commissioning group controls;
* The liabilities the clinical commissioning group incurs;
* The expenses the clinical commissioning group incurs; and
* The clinical commissioning group's share of the income from the pooled budget activities

If the clinical commissioning group is involved in a "jointly controlled assets" arrangement, in addition to the above, the clinical commissioning group recognises:

* The clinical commissioning group's share of the jointly controlled assets (classified according to the nature of the assets);
* The clinical commissioning group's share of any liabilities incurred jointly; and
* The clinical commissioning group's share of the expenses jointly incurred.

1.6 Critical Accounting Judgements & Key Sources of Estimation Uncertainty

In the application of the clinical commissioning group's accounting policies, management has made judgements, estimates and assumptions about the carrying amounts of assets and liabilities that are not readily apparent from other sources. The estimates and associated assumptions are based on historical experience and other factors that are considered to be relevant. Actual results may differ from those estimates and the estimates and underlying assumptions are continually reviewed. Revisions to accounting estimates are recognised in the period in which the estimate is revised if the revision affects only that period or in the period of the revision and future periods if the revision affects both current and future periods.

1.6.1 Critical Judgements in Applying Accounting Policies

The following critical judgement has a significant effect on the amounts recognised in the financial statements and has been made in the process of applying the clinical commissioning group's accounting policies. This judgement is in addition to estimations (see below):

Accruals have been included in the financial statements to the extent that the CCG recognises an obligation as at 31 March 2016 for which it has not been invoiced. Estimates of accruals are undertaken by management based on information available at the end of the financial year , together with past experience.

The CCG has reviewed the terms of the Better Care Fund. A Section 75 agreement is in place and the CCG can expend resources without reference to the other members (Kent County Council) and has full control over its element of the budget. The CCG commissions directly as if the pooled budget does not exist and so is outside the pooled budget arrangement. The expenditure by the CCG on the Better Care Fund in the year from 1st April 2015 to 31 March 2016 (2015/16) is £9,699,000.

1.6.2 Key Sources of Estimation Uncertainty

The following key estimations have been made by management in the process of applying the clinical commissioning group's accounting policies which have the most significant effect on the amounts recognised in the financial statements:

Some of the clinical commissioning group’s contracts are not brought to a formal conclusion until late June or early July each year. The clinical commissioning group made estimates on these contracts using the expertise of the commissioning support unit's contracts department.

GP drugs usage is also not known fully until 2 months after the year end. Estimates based on the Prescription Pricing Authority's annual expenditure phasings are made.

1.7 Revenue

Revenue in respect of services provided is recognised when, and to the extent that, performance occurs, and is measured at the fair value of the consideration receivable.

Where income is received for a specific activity that is to be delivered in the following year, that income is deferred.

1.8 Employee Benefits

1.8.1 Short-term Employee Benefits

Salaries, wages and employment-related payments are recognised in the period in which the service is received from employees, including bonuses earned but not yet taken.

The cost of leave earned but not taken by employees at the end of the period is recognised in the financial statements to the extent that employees are permitted to carry forward leave into the following period.

1.8.2 Retirement Benefit Costs

Past and present employees are covered by the provisions of the NHS Pensions Scheme. The scheme is an unfunded, defined benefit scheme that covers NHS employers, General Practices and other bodies, allowed under the direction of the Secretary of State, in England and Wales. The scheme is not designed to be run in a way that would enable NHS bodies to identify their share of the underlying scheme assets and liabilities. Therefore, the scheme is accounted for as if it were a defined contribution scheme: the cost to the clinical commissioning group of participating in the scheme is taken as equal to the contributions payable to the scheme for the accounting period.

For early retirements other than those due to ill health the additional pension liabilities are not funded by the scheme. The full amount of the liability for the additional costs is charged to expenditure at the time the clinical commissioning group commits itself to the retirement, regardless of the method of payment.

1.9 Other Expenses

Other operating expenses are recognised when, and to the extent that, the goods or services have been received. They are measured at the fair value of the consideration payable.

1.10 Property, Plant & Equipment

1.10.1 Recognition

Property, plant and equipment is capitalised if:

* It is held for use in delivering services or for administrative purposes;
* It is probable that future economic benefits will flow to, or service potential will be supplied to the clinical commissioning group;
* It is expected to be used for more than one financial year;
* The cost of the item can be measured reliably; and,
* The item has a cost of at least £5,000; or,

* Collectively, a number of items have a cost of at least £5,000 and individually have a cost of more than £250, where the assets are functionally interdependent, they had broadly simultaneous purchase dates, are anticipated to have simultaneous disposal dates and are under single managerial control; or,

* Items form part of the initial equipping and setting-up cost of a new building, ward or unit, irrespective of their individual or collective cost.

Where a large asset, for example a building, includes a number of components with significantly different asset lives, the components are treated as separate assets and depreciated over their own useful economic lives.

1.10.2 Valuation

All property, plant and equipment are measured initially at cost, representing the cost directly attributable to acquiring or constructing the asset and bringing it to the location and condition necessary for it to be capable of operating in the manner intended by management. All assets are measured subsequently at their current value at existing use.

Fixtures and equipment are carried at depreciated historic cost as this is not considered to be materially different from current value in existing use.

1.11 Depreciation, Amortisation & Impairments

Depreciation is charged to write off the costs of fixtures, plant and equipment non-current assets, less any residual value, over their estimated useful lives, in a manner that reflects the consumption of economic benefits or service potential of the assets. The estimated useful life of an asset is the period over which the clinical commissioning group expects to obtain economic benefits or service potential from the asset. This is specific to the clinical commissioning group and may be shorter than the physical life of the asset itself. Estimated useful lives and residual values are reviewed each year end, with the effect of any changes recognised on a prospective basis.

At each reporting period end, the clinical commissioning group checks whether there is any indication that any of its non-current assets have suffered an impairment loss. If there is indication of an impairment loss, the recoverable amount of the asset is estimated to determine whether there has been a loss and, if so, its amount. Intangible assets not yet available for use are tested for impairment annually.

1.12 Leases

Leases are classified as finance leases when substantially all the risks and rewards of ownership are transferred to the lessee. All other leases are classified as operating leases.

1.13 The Clinical Commissioning Group as Lessee

Property, plant and equipment held under finance leases are initially recognised, at the inception of the lease, at fair value or, if lower, at the present value of the minimum lease payments, with a matching liability for the lease obligation to the lessor. Lease payments are apportioned between finance charges and reduction of the lease obligation so as to achieve a constant rate on interest on the remaining balance of the liability. Finance charges are recognised in calculating the clinical commissioning group's surplus/deficit.

Operating lease payments are recognised as an expense on a straight-line basis over the lease term. Lease incentives are recognised initially as a liability and subsequently as a reduction of rentals on a straight-line basis over the lease term.
Contingent rentals are recognised as an expense in the period in which they are incurred.

1.14 Cash & Cash Equivalents

Cash is cash in hand and deposits with any financial institution repayable without penalty on notice of not more than 24 hours. Cash equivalents are investments that mature in 3 months or less from the date of acquisition and that are readily convertible to known amounts of cash with insignificant risk of change in value.

In the Statement of Cash Flows, cash and cash equivalents are shown net of bank overdrafts that are repayable on demand and that form an integral part of the clinical commissioning group's cash management.

1.15 Provisions

Provisions are recognised when the clinical commissioning group has a present legal or constructive obligation as a result of a past event, it is probable that the clinical commissioning group will be required to settle the obligation, and a reliable estimate can be made of the amount of the obligation. The amount recognised as a provision is the best estimate of the expenditure required to settle the obligation at the end of the reporting period, taking into account the risks and uncertainties.

When some or all of the economic benefits required to settle a provision are expected to be recovered from a third party, the receivable is recognised as an asset if it is virtually certain that reimbursements will be received and the amount of the receivable can be measured reliably.

1.16 Clinical Negligence Costs

The NHS Litigation Authority operates a risk pooling scheme under which the clinical commissioning group pays an annual contribution to the NHS Litigation Authority which in return settles all clinical negligence claims. The contribution is charged to expenditure, for 2015/16 the contribution was £4,740 (2014/15 £4,739) . Although the NHS Litigation Authority is administratively responsible for all clinical negligence cases the legal liability remains with the clinical commissioning group. The NHSLA has not carried out any claims on behalf of the CCG in 2015/16.

1.17 Non-Clinical Risk Pooling

The clinical commissioning group participates in the Property Expenses Scheme and the Liabilities to Third Parties Scheme. Both are risk pooling schemes under which the clinical commissioning group pays an annual contribution to the NHS Litigation Authority and, in return, receives assistance with the costs of claims arising. The annual membership contributions, and any excesses payable in respect of particular claims are charged to operating expenses as and when they become due.

1.18 Continuing healthcare risk pooling

In 2014-15 a risk pool scheme was been introduced by NHS England for continuing healthcare claims, for claim periods prior to 31 March 2013. Under the scheme clinical commissioning group contribute annually to a pooled fund, which is used to settle the claims.

1.19 Contingencies

A contingent liability is a possible obligation that arises from past events and whose existence will be confirmed only by the occurrence or non-occurrence of one or more uncertain future events not wholly within the control of the clinical commissioning group, or a present obligation that is not recognised because it is not probable that a payment will be required to settle the obligation or the amount of the obligation cannot be measured sufficiently reliably. A contingent liability is disclosed unless the possibility of a payment is remote.

A contingent asset is a possible asset that arises from past events and whose existence will be confirmed by the occurrence or non-occurrence of one or more uncertain future events not wholly within the control of the clinical commissioning group. A contingent asset is disclosed where an inflow of economic benefits is probable.

Where the time value of money is material, contingencies are disclosed at their present value.

1.20 Financial Assets

Financial assets are recognised when the clinical commissioning group becomes party to the financial instrument contract or, in the case of trade receivables, when the goods or services have been delivered. Financial assets are derecognised when the contractual rights have expired or the asset has been transferred.

Financial assets are classified into the following categories:

* Financial assets at fair value through profit and loss;
* Held to maturity investments;
* Available for sale financial assets; and,
* Loans and receivables.

The classification depends on the nature and purpose of the financial assets and is determined at the time of initial recognition.

1.20.1 Loans & Receivables

Loans and receivables are non-derivative financial assets with fixed or determinable payments which are not quoted in an active market. After initial recognition, they are measured at amortised cost using the effective interest method, less any impairment. Interest is recognised using the effective interest method.
Fair value is determined by reference to quoted market prices where possible, otherwise by valuation techniques.

The effective interest rate is the rate that exactly discounts estimated future cash receipts through the expected life of the financial asset, to the initial fair value of the financial asset.

At the end of the reporting period, the clinical commissioning group assesses whether any financial assets, other than those held at ‘fair value through profit and loss’ are impaired. Financial assets are impaired and impairment losses recognised if there is objective evidence of impairment as a result of one or more events which occurred after the initial recognition of the asset and which has an impact on the estimated future cash flows of the asset.

For financial assets carried at amortised cost, the amount of the impairment loss is measured as the difference between the asset’s carrying amount and the present value of the revised future cash flows discounted at the asset’s original effective interest rate. The loss is recognised in expenditure and the carrying amount of the asset is reduced through a provision for impairment of receivables.

If, in a subsequent period, the amount of the impairment loss decreases and the decrease can be related objectively to an event occurring after the impairment was recognised, the previously recognised impairment loss is reversed through expenditure to the extent that the carrying amount of the receivable at the date of the impairment is reversed does not exceed what the amortised cost would have been had the impairment not been recognised.

1.21 Financial Liabilities

Financial liabilities are recognised on the statement of financial position when the clinical commissioning group becomes party to the contractual provisions of the financial instrument or, in the case of trade payables, when the goods or services have been received. Financial liabilities are de-recognised when the liability has been discharged, that is, the liability has been paid or has expired.

1.21.1 Financial Guarantee Contract Liabilities

Financial guarantee contract liabilities are subsequently measured at the higher of:

* The premium received (or imputed) for entering into the guarantee less cumulative amortisation; and,
* The amount of the obligation under the contract, as determined in accordance with IAS 37: Provisions, Contingent Liabilities and Contingent Assets.

1.21.2 Other Financial Liabilities

After initial recognition, all other financial liabilities are measured at amortised cost using the effective interest method, except for loans from Department of Health, which are carried at historic cost. The effective interest rate is the rate that exactly discounts estimated future cash payments through the life of the asset, to the net carrying amount of the financial liability. Interest is recognised using the effective interest method.

1.22 Value Added Tax

Most of the activities of the clinical commissioning group are outside the scope of VAT and, in general, output tax does not apply and input tax on purchases is not recoverable. Irrecoverable VAT is charged to the relevant expenditure category or included in the capitalised purchase cost of fixed assets. Where output tax is charged or input VAT is recoverable, the amounts are stated net of VAT.

1.23 Accounting Standards That Have Been Issued But Have Not Yet Been Adopted

The Government Financial Reporting Manual does not require the following Standards and Interpretations to be applied in 2015-16, all of which are subject to consultation:

* IFRS 9: Financial Instruments
* IFRS 14: Regulatory Deferral Accounts
* IFRS 15: Revenue for Contract with Customers

The application of the Standards as revised would not have a material impact on the accounts for 2015-16, were they applied in that year.

2. Other Operating Revenue

	2015-16 Total £000	2015-16 Admin £000	2015-16 Programme £000	2014-15 Total £000
Charitable and other contributions to revenue expenditure: non-NHS	15	15	0	5
Non-patient care services to other bodies	10	0	10	0
Other revenue	433	15	418	580
Total other operating revenue	**458**	**30**	**428**	**585**

Other Revenue comprises prescribing rebates

Revenue in this note does not include cash received from NHS England which is drawn down directly into the bank account of the CCG and credited to the general fund

3 Revenue

	2015-16 Total £000	2015-16 Admin £000	2015-16 Programme £000	2014-15 Total £000
From rendering of services	458	30	428	585
Total	**458**	**30**	**428**	**585**

Revenue is totally from the supply of services. The clinical commissioning group receives no revenue from the supply of goods.

4. Employee benefits and staff numbers

4.1.1 Employee benefits — 2015-16

	Total			Admin			Programme		
	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000
Employee Benefits									
Salaries and wages	1,290	1,265	25	1,053	1,028	25	237	237	0
Social security costs	122	122	0	105	105	0	17	17	0
Employer Contributions to NHS Pension scheme	186	186	0	156	156	0	30	30	0
Termination benefits	13	13	0	13	13	0	0	0	0
Gross employee benefits expenditure	**1,611**	**1,586**	**25**	**1,327**	**1,302**	**25**	**284**	**284**	**0**
Less recoveries in respect of employee benefits (note 4.1.2)	0	0	0	0	0	0	0	0	0
Total - Net admin employee benefits including capitalised costs	**1,611**	**1,586**	**25**	**1,327**	**1,302**	**25**	**284**	**284**	**0**
Less: Employee costs capitalised	0	0	0	0	0	0	0	0	0
Net employee benefits excluding capitalised costs	**1,611**	**1,586**	**25**	**1,327**	**1,302**	**25**	**284**	**284**	**0**

4.1.1 Employee benefits — 2014-15

	Total			Admin			Programme		
	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000	Total £000	Permanent Employees £000	Other £000
Employee Benefits									
Salaries and wages	1,129	1,108	21	978	957	21	151	151	0
Social security costs	105	105	0	105	105	0	0	0	0
Employer Contributions to NHS Pension scheme	142	142	0	142	142	0	0	0	0
Termination benefits	51	51	0	51	51	0	0	0	0
Gross employee benefits expenditure	**1,427**	**1,406**	**21**	**1,276**	**1,255**	**21**	**151**	**151**	**0**
Less recoveries in respect of employee benefits (note 4.1.2)	0	0	0	0	0	0	0	0	0
Total - Net admin employee benefits including capitalised costs	**1,427**	**1,406**	**21**	**1,276**	**1,255**	**21**	**151**	**151**	**0**
Less: Employee costs capitalised	0	0	0	0	0	0	0	0	0
Net employee benefits excluding capitalised costs	**1,427**	**1,406**	**21**	**1,276**	**1,255**	**21**	**151**	**151**	**0**

The remuneration and staff report included within the annual report provides details of the payments made to more senior employees

4.2 Average number of people employed

	2015-16 Total Number	2015-16 Permanently employed Number	2015-16 Other Number	2014-15 Total Number
Total	**49**	**48**	**1**	**39**
Of the above: Number of whole time equivalent people engaged on capital projects	**0**	**0**	**0**	0

4.3 Staff sickness absence and ill health retirements

	2015-16 Number	2014-15 Number
Total Days Lost	172	104
Total Staff Years	32	28
Average working Days Lost	**5**	**4**

	2015-16 Number	2014-15 Number
Number of persons retired early on ill health grounds	0	0
	£000	**£000**
Total additional Pensions liabilities accrued in the year	0	0

Ill health retirement costs are met by the NHS Pension Scheme

4.4 Exit packages agreed in the financial year

	2015-16 Compulsory redundancies		2015-16 Other agreed departures		2015-16 Total	
	Number	£	Number	£	Number	£
Less than £10,000	0	0	0	0	0	0
£10,001 to £25,000	0	0	0	0	0	0
£25,001 to £50,000	0	0	0	0	0	0
£50,001 to £100,000	0	0	0	0	0	0
£100,001 to £150,000	0	0	0	0	0	0
£150,001 to £200,000	0	0	0	0	0	0
Over £200,001	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**

	2014-15 Compulsory redundancies		2014-15 Other agreed departures		2014-15 Total	
	Number	£	Number	£	Number	£
Less than £10,000	0	0	0	0	0	0
£10,001 to £25,000	0	0	0	0	0	0
£25,001 to £50,000	0	0	0	0	0	0
£50,001 to £100,000	1	54,913	0	0	1	54,913
£100,001 to £150,000	0	0	0	0	0	0
£150,001 to £200,000	0	0	0	0	0	0
Over £200,001	0	0	0	0	0	0
Total	**1**	**54,913**	**0**	**0**	**1**	**54,913**

4.5 Pension costs

Past and present employees are covered by the provisions of the NHS Pension Scheme. Details of the benefits payable under these provisions can be found on the NHS Pensions website at www.nhsbsa.nhs.uk/Pensions.

bodies, allowed under the direction of the Secretary of State, in England and Wales. The Scheme is not designed to be run in a way that would enable NHS bodies to identify their share of the underlying scheme assets and liabilities.

Therefore, the Scheme is accounted for as if it were a defined contribution scheme: the cost to the clinical commissioning group of participating in the Scheme is taken as equal to the contributions payable to the

The Scheme is subject to a full actuarial valuation every four years (until 2004, every five years) and an accounting valuation every year. An outline of these follows:

4.5.1 Full actuarial (funding) valuation

The purpose of this valuation is to assess the level of liability in respect of the benefits due under the Scheme (taking into account its recent demographic experience), and to recommend the contribution rates to be paid by employers and scheme members. The last such valuation, which determined current contribution rates was undertaken as at 31 March 2012 and covered the period from 1 April 2008 to that date. Details can be found on the pension scheme website at www.nhsbsa.nhs.uk/pensions.

For 2015-16, employers' contributions of £206,466 were payable to the NHS Pensions Scheme (2014-15: £165,918) were payable to the NHS Pension Scheme at the rate of 14.3% of pensionable pay. The scheme's actuary reviews employer contributions, usually every four years and now based on HMT Valuation Directions, following a full scheme valuation. The latest review used data from 31 March 2012 and was published on the Government website on 9 June 2014.

5. Operating expenses

	2015-16 Total £000	2015-16 Admin £000	2015-16 Programme £000	2014-15 Total £000
Gross employee benefits				
Employee benefits excluding governing body members	1,422	1,138	284	1,274
Executive governing body members	189	189	0	153
Total gross employee benefits	**1,611**	**1,327**	**284**	**1,427**
Other costs				
Services from other CCGs and NHS England	1,340	952	388	1,563
Services from foundation trusts	122,745	1	122,744	105,704
Services from other NHS trusts	17,344	0	17,344	32,322
Services from other NHS bodies	0	0	0	0
Purchase of healthcare from non-NHS bodies	28,152	0	28,152	24,552
Chair and Non Executive Members	373	373	0	355
Supplies and services – clinical	2,449	0	2,449	2,132
Supplies and services – general	628	51	578	430
Consultancy services	90	90	0	225
Establishment	409	97	312	551
Transport	6	6	0	4
Premises	465	13	452	524
Impairments and reversals of receivables	0.00	0.00	0	0
Depreciation	5	5	0	5
Amortisation	0	0	0	0
Audit fees	56	56	0	74
Other non statutory audit expenditure				
· Internal audit services	6	6	0	0
· Other services	0	0	0	0
Prescribing costs	26,704	0	26,704	25,380
General ophthalmic services	5	0	5	2
GPMS/APMS and PCTMS	1,248	0	1,248	1,211
Other professional fees excl. audit	210	125	85	176
Clinical negligence	0	0	0	0
Education and training	41	41	0	24
Provisions	- 115	0	- 115	262
CHC Risk Pool contributions	744	0	744	284
Other expenditure	0	0	0	0
Total other costs	**202,906**	**1,816**	**201,090**	**195,779**
Total operating expenses	**204,517**	**3,143**	**201,374**	**197,206**

6.1 Better Payment Practice Code

Measure of compliance	2015-16 Number	2015-16 £000	2014-15 Number	2014-15 £000
Non-NHS Payables				
Total Non-NHS Trade invoices paid in the Year	8,178	44,447	6,691	32,279
Total Non-NHS Trade Invoices paid within target	7,864	43,567	6,511	30,814
Percentage of Non-NHS Trade invoices paid within target	**96.16%**	**98.02%**	**97.31%**	**95.46%**
NHS Payables				
Total NHS Trade Invoices Paid in the Year	2,252	140,028	2,392	142,278
Total NHS Trade Invoices Paid within target	2,214	139,792	2,360	141,828
Percentage of NHS Trade Invoices paid within target	**98.31%**	**99.83%**	**98.66%**	**99.68%**

6.2 The Late Payment of Commercial Debts (Interest) Act 1998

	2015-16 £000	2014-15 £000
Amounts included in finance costs from claims made under this legislation	0	0
Compensation paid to cover debt recovery costs under this legislation	0	0
Total	**0**	**0**

7. Operating Leases

7.1 As lessee

The clinical commissioning group holds two leases with Thanet District Council for the use of two offices within the council builing for a five year term. Both leases cease on 31st March 2021 when the offices will either be vacated or a new lease term will be re-negotiated.

All other property assets are owned by NHS Properrty Services Limited and the charge is based on usage of local premises by providers within our geographical area.

7.1.1 Payments recognised as an Expense

				2015-16				2014-15
	Land	Buildings	Other	Total	Land	Buildings	Other	Total
	£000	£000	£000	£000	£000	£000	£000	£000
Payments recognised as an expense								
Minimum lease payments	0	467	0	**467**	0	501	1	**502**
Contingent rents	0	0	0	**0**	0	0	0	**0**
Sub-lease payments	0	0	0	**0**	0	0	0	**0**
Total	**0**	**467**	**0**	**467**	**0**	**501**	**1**	**502**

7.1.2 Future minimum lease payments

				2015-16				2014-15
	Land	Buildings	Other	Total	Land	Buildings	Other	Total
	£000	£000	£000	£000	£000	£000	£000	£000
Payable:								
No later than one year	0	24	0	**24**	0	0	0	**0**
Between one and five years	0	93	0	**93**	0	0	0	**0**
After five years	0	0	0	**0**	0	0	0	**0**
Total	**0**	**117**	**0**	**117**	**0**	**0**	**0**	**0**

Whilst our arrangements with NHS Property Services Limited fall within the definition of operating leases, rental charge for future years has not yet been agreed . Consequently this note does not include future minimum lease payments for properties owned by NHS Property Services.

8. Property, plant and equipment

2015-16	Buildings excluding dwellings £000	Information technology £000	Furniture & fittings £000	Total £000
Cost or valuation at 01-April-2015	0	0	24	24
Additions purchased	83	15	10	108
Cost/Valuation At 31-March-2016	**83**	**15**	**34**	**132**
Depreciation 01-April-2015	0	0	9	9
Charged during the year	0	0	5	5
Depreciation at 31-March-2016	**0**	**0**	**14**	**14**
Net Book Value at 31-March-2016	**83**	**15**	**20**	**118**
Purchased	83	15	20	118
Total at 31-March-2016	**83**	**15**	**20**	**118**
Asset financing:				
Owned	83	15	20	118
Total at 31-March-2016	**83**	**15**	**20**	**118**

2014-15	Buildings excluding dwellings £000	Information technology £000	Furniture & fittings £000	Total £000
Cost or valuation at 01-April-2014	0	0	24	24
Additions purchased	0	0	0	0
Cost/Valuation At 31-March-2015	**0**	**0**	**24**	**24**
Depreciation 01-April-2014	0	0	5	5
Charged during the year	0	0	4	4
Depreciation at 31-March-2015	**0**	**0**	**9**	**9**
Net Book Value at 31-March-2015	**0**	**0**	**15**	**15**
Purchased	0	0	15	15
Total at 31-March-2015	**0**	**0**	**15**	**15**
Asset financing:				
Owned	0	0	15	15
Total at 31-March-2015	**0**	**0**	**15**	**15**

The addition of £83,000 shown in Buildings excluding dwelling relates to the refurbishment of a new leased property. This lease is for 5 years

8 Property, plant and equipment cont'd

8.1 Economic lives

	Minimum Life (years)	Maximum Life (Years)
Buildings excluding dwellings	5	5
Information technology	3	3
Furniture & fittings	5	5

9. Trade and other receivables

	Current 2015-16 £000	Current 2014-15 £000
NHS receivables: Revenue	890	558
NHS prepayments	364	452
NHS accrued income	80	198
Non-NHS receivables: Revenue	494	35
Non-NHS prepayments	120	83
Non-NHS accrued income	371	81
VAT	30	33
Other receivables	0	2
Total Trade & other receivables	**2,349**	**1,442**
Total current and non current	**2,349**	**1,442**

9.1 Receivables past their due date but not impaired

	2015-16 £000	2014-15 £000
By up to three months	418	46
By three to six months	363	2
By more than six months	3	0
Total	**784**	**48**

10. Cash and cash equivalents

	2015-16 £000	2014-15 £000
Balance at 01-April-2015	71	15
Net change in year	(26)	56
Balance at 31-March-2016	**45**	**71**
Made up of:		
Cash with the Government Banking Service	45	71
Cash in hand	0	(0)
Cash and cash equivalents as in statement of financial position	**45**	**71**
Balance at 31-March-2016	**45**	**71**

No Patients' money is held by the clinical commissioning group.

11. Trade and other payables

	Current 2015-16 £000	Current 2014-15 £000
NHS payables: revenue	2,308	2,648
NHS accruals	1,337	779
Non-NHS payables: revenue	3,561	2,270
Non-NHS accruals	6,634	7,944
Social security costs	24	22
Tax	26	29
Other payables	654	369
Total Trade & Other Payables	**14,544**	**14,061**
Total current and non-current	**14,544**	**14,061**

Other payables include £35,240 (£25,320 2014/15) outstanding pension contributions at 31 March 2016

12. Provisions

	Current 2015-16 £000	Current 2014-15 £000
Continuing care	65	262
Total	**65**	**262**
Total current and non-current	**65**	**262**

	Continuing Care £000s	Total £000s
Balance at 01-April-2015	**262**	**262**
Arising during the year	0	0
Utilised during the year	(83)	(83)
Reversed unused	(115)	(115)
Balance at 31-March-2016	**65**	**65**
Expected timing of cash flows:		
Within one year	65	65
Balance at 31-March-2016	**65**	**65**

This provision relates to Continuing Health Care Retrospective claims outstanding for 2013/14 and 2014/15. This includes claims agreed awaiting settlement as well as pending cases.

13. Contingencies

The Clinical Commissioning Group has no significant contingent liabilities or assets as at 31 March 2016. (31 March 2015 - Nil).

14. Commitments

14.1 Other financial commitments

The NHS Clinical Commissioning Group has entered into contracts with values exceeding £1 million. All contracts are standard NHS contracts which includes break clauses. These clauses are of 12 months or less and are therefore not recognised as financial commitments.

15. Financial instruments

15.1 Financial risk management

Financial reporting standard IFRS 7 requires disclosure of the role that financial instruments have had during the period in creating or changing the risks a body faces in undertaking its activities.

Because the NHS Clinical Commissioning Group is financed through parliamentary funding, it is not exposed to the degree of financial risk faced by business entities. Also, financial instruments play a much more limited role in creating or changing risk than would be typical of listed companies, to which the financial reporting standards mainly apply. The clinical commissioning group has limited powers to borrow or invest surplus funds and financial assets and liabilities are generated by day-to-day operational activities rather than being held to change the risks facing the clinical commissioning group in undertaking its activities.

Treasury management operations are carried out by the finance department, within parameters defined formally within the NHS Clinical Commissioning Group standing financial instructions and policies agreed by the Governing Body. Treasury activity is subject to review by the NHS Clinical Commissioning Group and internal auditors.

15.1.2 Interest rate risk

The Clinical Commissioning Group borrows from government for capital expenditure, subject to affordability as confirmed by NHS England. The borrowings are for 1 to 25 years, in line with the life of the associated assets, and interest is charged at the National Loans Fund rate, fixed for the life of the loan. The clinical commissioning group therefore has low exposure to interest rate fluctuations.

15.1.3 Credit risk

Because the majority of the NHS Clinical Commissioning Group and revenue comes parliamentary funding, NHS Clinical Commissioning Group has low exposure to credit risk. The maximum exposures as at the end of the financial year are in receivables from customers, as disclosed in the trade and other receivables note.

15.1.3 Liquidity risk

NHS Clinical Commissioning Group is required to operate within revenue and capital resource limits, which are financed from resources voted annually by Parliament. The NHS Clinical Commissioning Group draws down cash to cover expenditure, as the need arises. The NHS Clinical Commissioning Group is not, therefore, exposed to significant liquidity risks.

15. Financial instruments cont'd

15.2 Financial assets

	Loans and Receivables 2015-16 £000	Total 2015-16 £000
Receivables:		
· NHS	969	969
· Non-NHS	865	865
Cash at bank and in hand	45	45
Total at 31-March-2016	**1,879**	**1,879**

	Loans and Receivables 2014-15 £000	Total 2014-15 £000
Receivables:		
· NHS	756	756
· Non-NHS	116	116
Cash at bank and in hand	71	71
Other financial assets	2	2
Total at 31-March-2016	**945**	**945**

15.3 Financial liabilities

	Other 2015-16 £000	Total 2015-16 £000
Payables:		
· NHS	3,644	3,644
· Non-NHS	10,849	10,849
Total at 31-March-2016	**14,493**	**14,493**

	Other 2014-15 £000	Total 2014-15 £000
Payables:		
· NHS	3,427	3,427
· Non-NHS	10,582	10,582
Total at 31-March-2016	**14,009**	**14,009**

There is no difference between the carrying value of financial assets and liabilities and their fair value.

As at 31 March 2016 all financial liabilities are due within one year (31 March 2015 - All due within one year)

16. Operating segments

The clinical commissioning group considers it has only one segment: commissioning of healthcare services.

	Gross expenditure £'000	Income £'000	Net expenditure £'000	Total assets £'000	Total liabilities £'000	Net assets £'000
Commissioning of Healthcare	204,519	(458)	**204,061**	2,511	(14,608)	(12,097)
Total	**204,519**	**(458)**	**204,061**	**2,511**	**(14,608)**	**(12,097)**

17. Pooled budgets

The NHS Clinical Commissioning Group's share of the income and expenditure handled by the pooled budget in the financial year were:

	2015-16	2014-15
	£000	£000
Expenditure	(2,083)	(1,843)

In 2003, the former Eastern and Coastal Kent Primary Care Trust entered into a s75 pooled budget arrangement with Kent County Council (KCC) for the provision of an integrated social care centre at Westbrook House, Margate. Following the dissolution of the PCT, the health contribution to this centre is now being provided by the Thanet CCG. Thanet CCG has included within its expenditure £1,993,504 in respect of its contributions to this s75 agreement as a revenue contribution. The other element of the pooled budget relates to the Integrated Community Equipment Service (ICES). This is subject to a s75 agreement with KCC. In 2014-15 the s75 agreement was between KCC and Kent Community Health Foundation Trust. The value of this is £89,300.

The CCG has reviewed the contractual terms of the Better Care Fund. The CCG commissions directly as if the pooled budget does not exist and it is therefore considered to be outside the pooled budget arrangment.

18. Related party transactions

Details of related party transactions with individuals are as follows:

	Payments to Related Party £000	Receipts from Related Party £000	Amounts owed to Related Party £000	Amounts due from Related Party £000
	0	0	0	0

The Department of Health is regarded as a related party. During the year the clinical commissioning group has had a significant number of material transactions (over £1million) with entities for which the Department is regarded as the parent Department. These entities are:

East Kent Hospitals University NHS Foundation Trust
Kent Community Health NHS Foundation Trust
Kent and Medway NHS and Social Care Partnership
South East Coast Ambulance Service NHS Foundation Trust
South East Commissioning Support
Sussex Partnership NHS Foundation Trust
Kings College Hospitals NHS Foundation Trust
Guys & St Thomas NHS Foundation Trust

In addition, the clinical commissioning group has had a number of material transactions with other government departments and other central and local government bodies. Most of these transactions have been with Kent County Council (KCC).

Payments have been made by the CCG to medical practices where members of the governing board are partners. These have not been disclosed as disclosure would infringe the privacy of the other partners in those practices.

19. Events after the end of the reporting period

Thanet CCG has no events after the reporting period

20. Financial performance targets

NHS Clinical Commissioning Group have a number of financial duties under the NHS Act 2006 (as amended).

NHS Clinical Commissioning Group performance against those duties was as follows:

	2015-16 Target	2015-16 Performance	2015-16 Variance	2015-16 Target Met	2014-15 Target	2014-15 Performance
Expenditure not to exceed income	206,724	204,627	(2,097)	Y	199,858	197,206
Capital resource use does not exceed the amount specified in Directions	108	108	0	Y	0	0
Revenue resource use does not exceed the amount specified in Directions	206,158	204,061	(2,097)	Y	199,273	196,621
Capital resource use on specified matter(s) does not exceed the amount specified in Directions	108	108	0	Y	n/a	n/a
Revenue resource use on specified matter(s) does not exceed the amount specified in Directions	n/a	n/a	n/a		n/a	n/a
Revenue administration resource use does not exceed the amount specified in Directions	3,213	3,114	(99)	Y	3,524	3,524

KENT PUBLIC HEALTH OBSERVATORY

THANET CCG

Analysis of Deprived Areas

In the most deprived decile for Kent

January 2016

KCC Public Health is taking a new approach to reducing health inequalities in the county, by producing focussed analysis of LSOAs in the most deprived decile. Multivariate segmentation techniques have been used to identify different 'types' of deprivation in Kent. This report shows our analysis of the most deprived areas in the Thanet CCG area. For more information on the rationale of this approach and our methods, please see the full report:

Produced by

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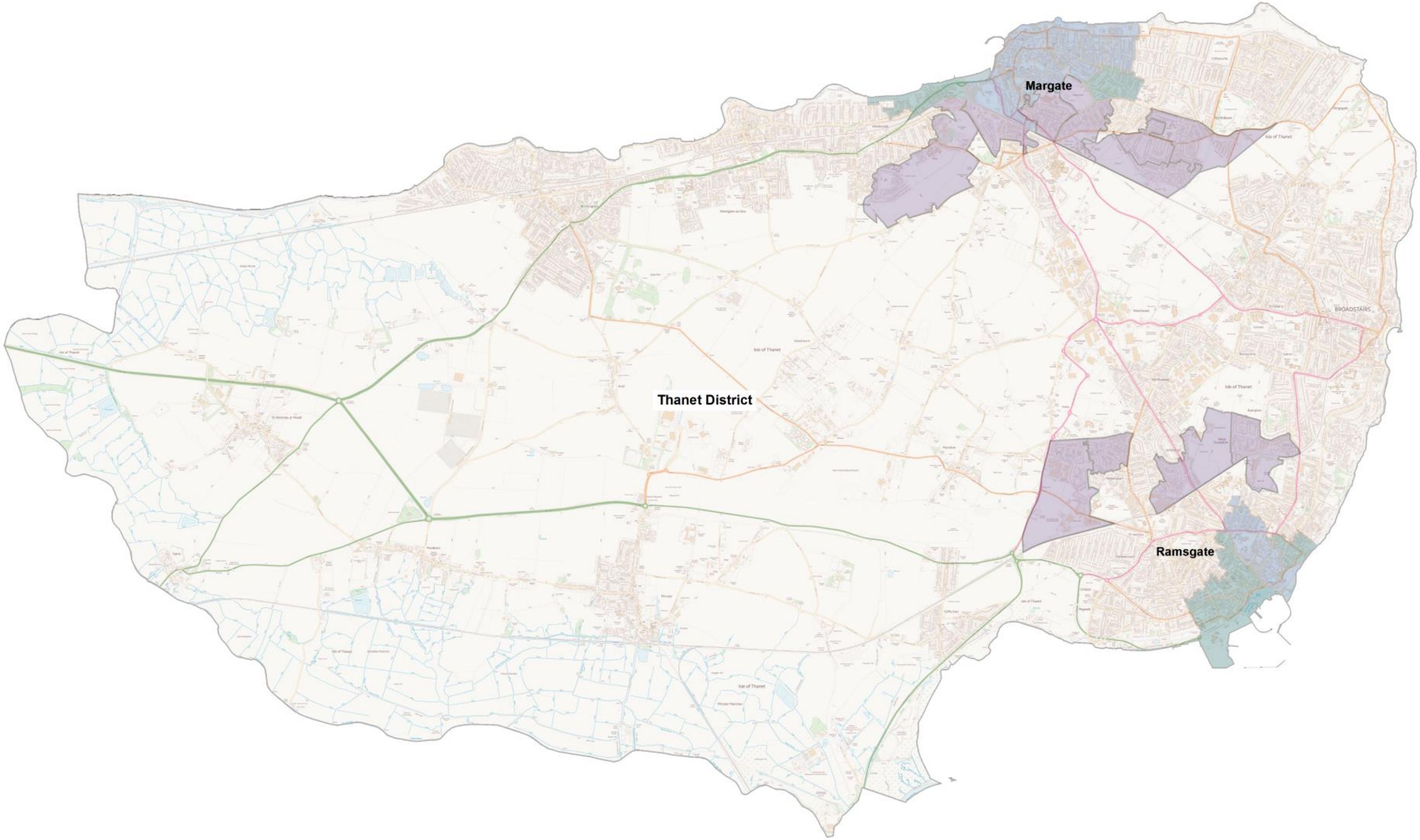
kent.gov.uk

Background

Thanet is an area in east Kent that includes the coastal towns of Margate, Ramsgate and Broadstairs and surrounding village areas. The Thanet CCG area is coterminous with the district boundaries. Deprivation, crime and unemployment are all statistically higher than the England average, with higher proportions of vulnerable populations. There are limited skilled employment opportunities in the area, although there are good transport links to Kent and London. Health outcomes are worse than for Kent and England, and inequalities are wider than in any other Kent district. A number of Thanet LSOAs feature in the most deprived decile for deprivation in Kent, mainly around the towns of Margate and Ramsgate.

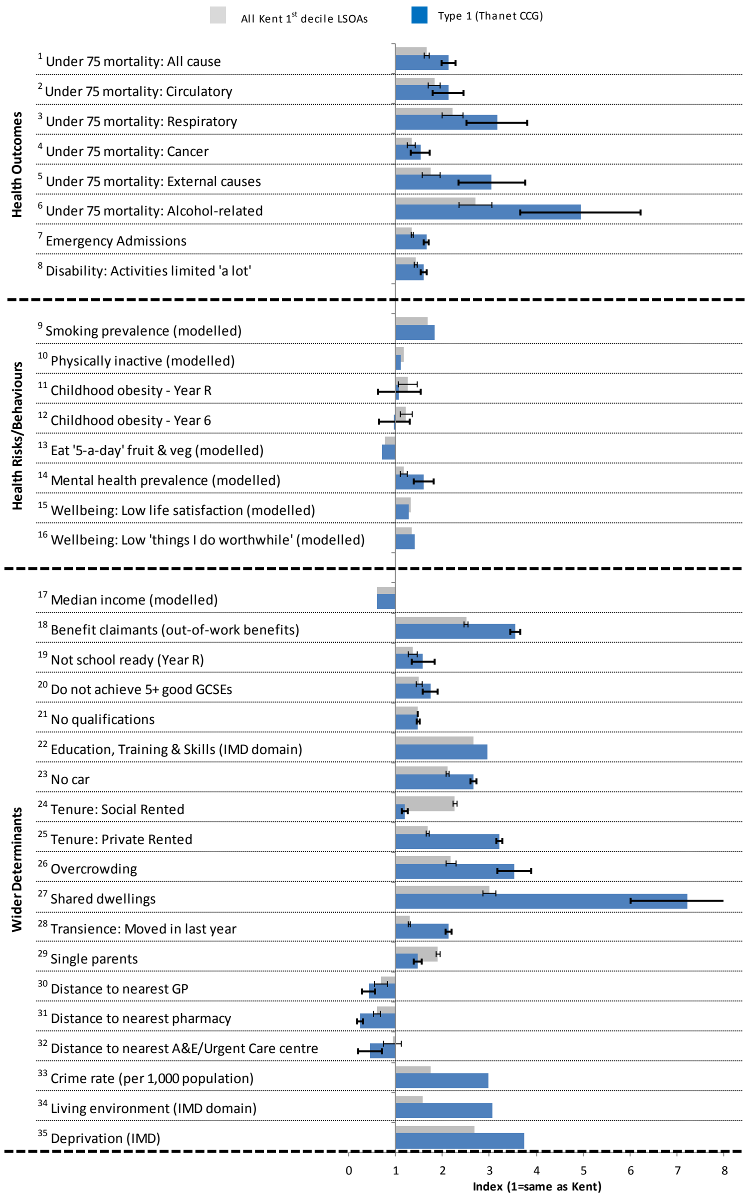
Deprived Areas

Ward Code	Ward Name	LSOA Code	LSOA Name	LSOA rank	GP Practice Code Serving LSOA			Type
E05005093	Margate Central	**E01024678**	**Thanet 001E**	2	G82052			1
		E01024676	**Thanet 003A**	3	G82052	G82649		1
		E01024677	**Thanet 003B**	65	G82052	G82066	G82105	3
E05005088	Cliftonville West	**E01024657**	**Thanet 001A**	1	G82105	G82052		1
		E01024660	**Thanet 001D**	5	G82105			1
		E01024658	**Thanet 001B**	6	G82105			1
		E01024661	**Thanet 004A**	22	G82052	G82105		1
		E01024659	**Thanet 001C**	42	G82105	G82066		4
E05005089	Dane Valley	**E01024663**	**Thanet 006D**	10	G82066			3
		E01024666	**Thanet 006E**	21	G82066			3
		E01024662	**Thanet 006C**	59	G82066			3
		E01024664	**Thanet 004B**	66	G82105	G82066	G82052	3
E05005091	Garlinge	**E01024672**	**Thanet 005A**	55	G82810	G82052		3
E05005090	Eastcliff	**E01024667**	**Thanet 016D**	9	G82126			1
		E01024670	**Thanet 015D**	44	G82126	G82020		1
		E01024671	**Thanet 016E**	36	G82126			4
E05005085	Central Harbour	**E01024649**	**Thanet 016C**	43	G82126	G82064	G82020	4
		E01024646	**Thanet 016A**	84	G82126	G82064	G82020	4
E05005095	Newington	**E01024683**	**Thanet 013B**	11	G82150			3
		E01024682	**Thanet 013A**	40	G82150	G82046		3
E05005096	Northwood	**E01024687**	**Thanet 013E**	17	G82046	G82150	G82020	3
E05005099	Sir Moses Montefiore	**E01024699**	**Thanet 012C**	62	G82126			3
E05005098	Salmestone	**E01024697**	**Thanet 003D**	34	G82052	G82066	G82649	3
E05005102	Westbrook	**E01024710**	**Thanet 003E**	15	G82810	G82052		4

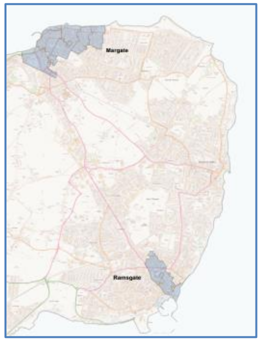

Margate
Thanet District
Ramsgate
BROADSTAIRS

Young people lacking opportunities

Thanet CCG
Type 1 Deprived LSOAs
Margate Central, Cliftonville West, Eastcliff



Prepared by KPHO (RK), Jan 2016



MAIN ISSUES

Characteristics

- Young adults in private rented accommodation
- Particularly high levels of shared dwellings and overcrowding
- Particularly poor living environment with particularly high crime rates
- Low incomes
- Particularly high levels of out-of-work benefit claimants
- Poor scores for education
- Particularly high levels of movement/ transiency

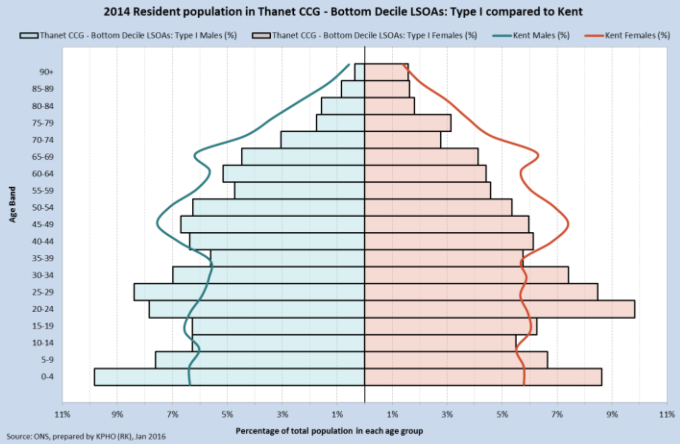
Health Risks/Behaviours

- High smoking prevalence
- Low levels of wellbeing

Health Outcomes

- Particularly high premature mortality rates
- Alcohol-related premature mortality and from 'external causes' and respiratory conditions particularly high
- Particularly high emergency hospital admission rates
- High rates of disability ('activities limited a lot')

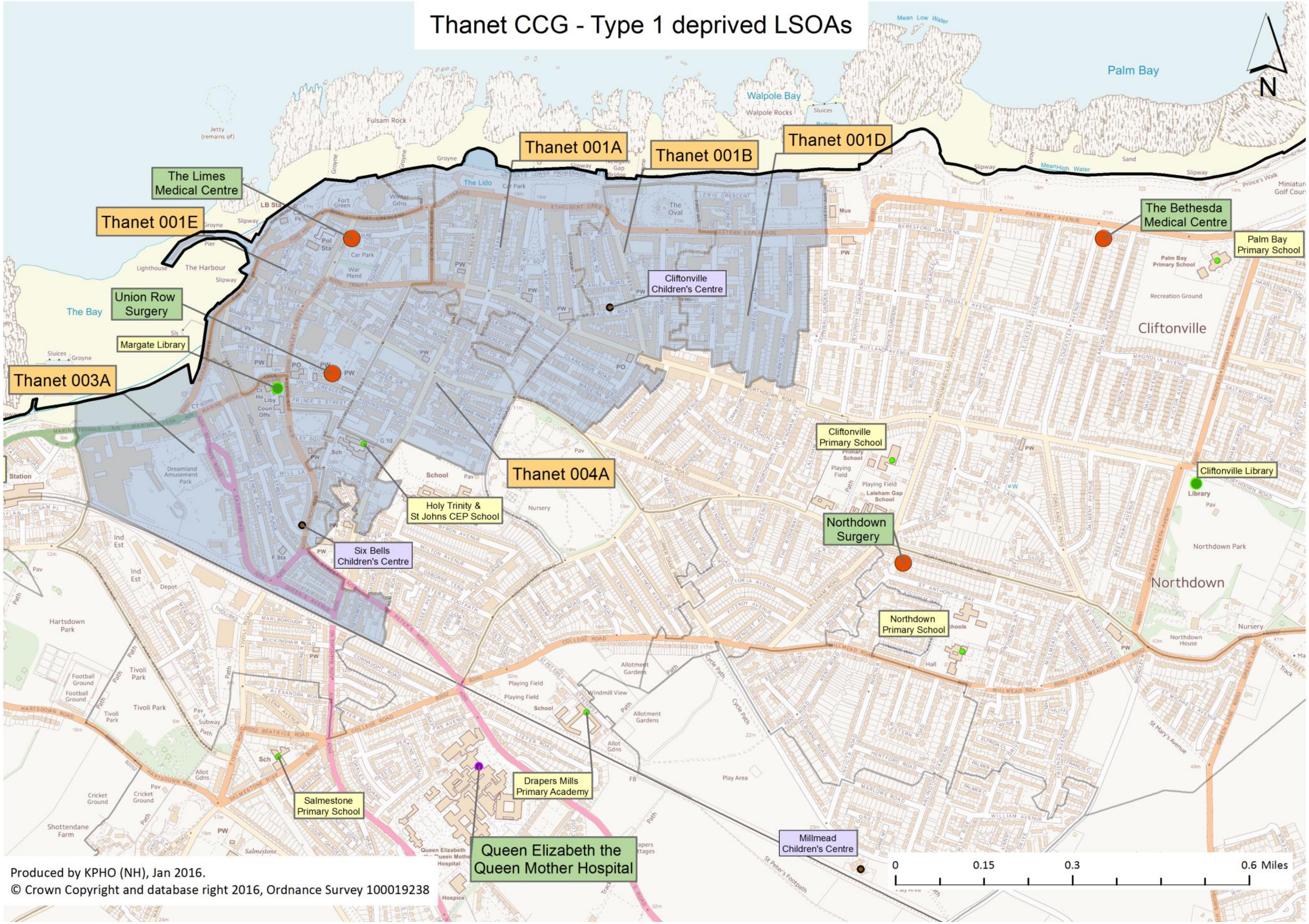
POPULATION DISTRIBUTION



- High numbers young adults and young children

KEY FOCUS AREAS:

Education and employment opportunities for young people



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Thanet CCG - Type 1 deprived LSOAs
Newington Road Surgery
Wickham Surgery
St Ethelberts Catholic Primary School
1. The Grange Medical Practice
2. East Cliff Practice
Thanet 015D
St Laurence in Thanet C of E Junior School
Ellington Infant School
Chatham & Clarendon Grammar School
Dashwood Medical Centre
Priory Infant School
Priory Children's Centre
Ramsgate Library
Icelands
Thanet 016D
Christ Church CEJ School
RAMSGATE
Newington
St Lawrence
Nethercourt
Chilton
Pegwell
N
0
0.15
0.3
0.6 Miles
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Thanet CCG
Type 3 Deprived LSOAs
Dane Valley, Garlinge, Newington

Families in social housing

MAIN ISSUES

Characteristics

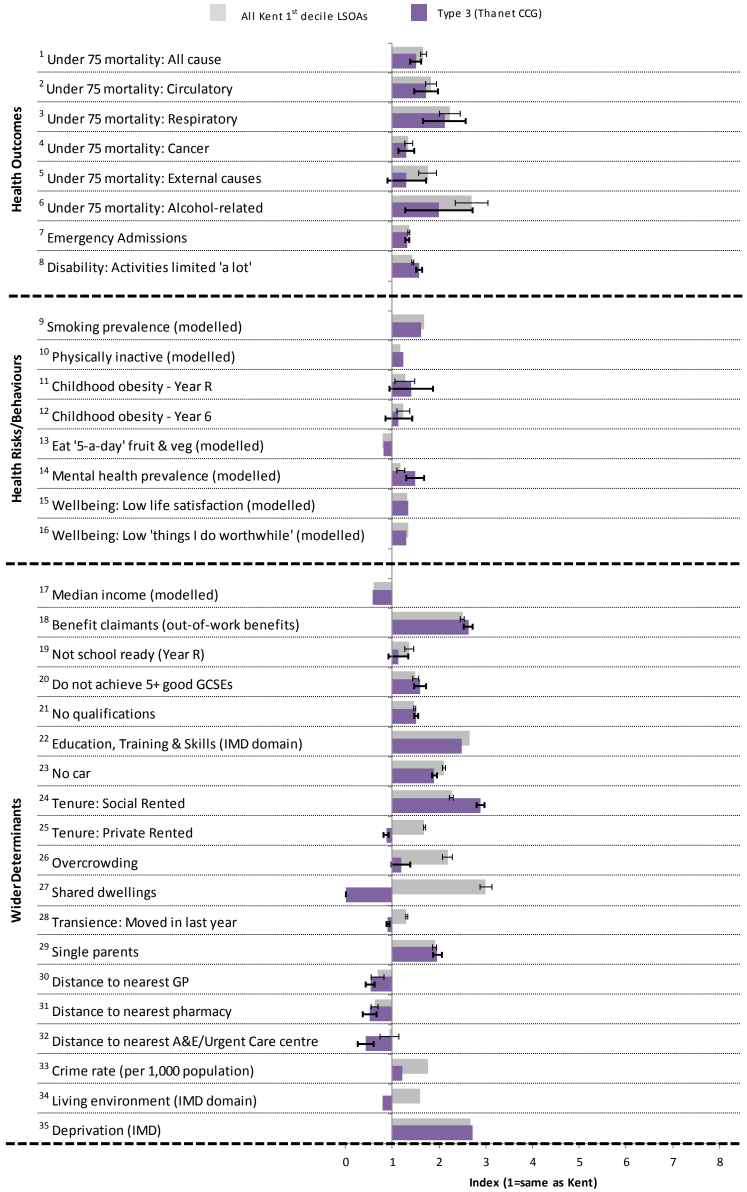
- Families with children in social housing
- Low incomes
- Poor scores for education
- High numbers of out-of-work benefits claimants
- High number of single parents
- Better living environment and lower crime rates than other deprived areas.

Health Risks/Behaviours

- High smoking prevalence
- Low levels of wellbeing.

Health Outcomes

- Fairly high premature mortality rates
- High emergency hospital admission rates
- High rates of disability ('activities limited a lot')



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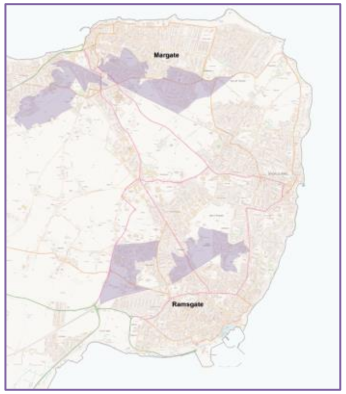
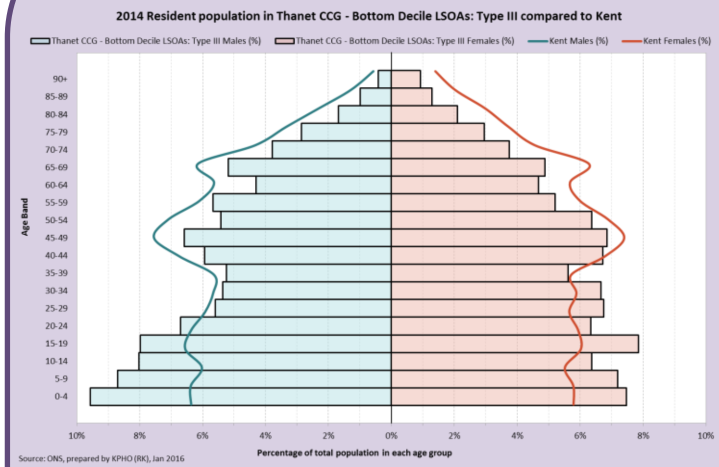


POPULATION DISTRIBUTION

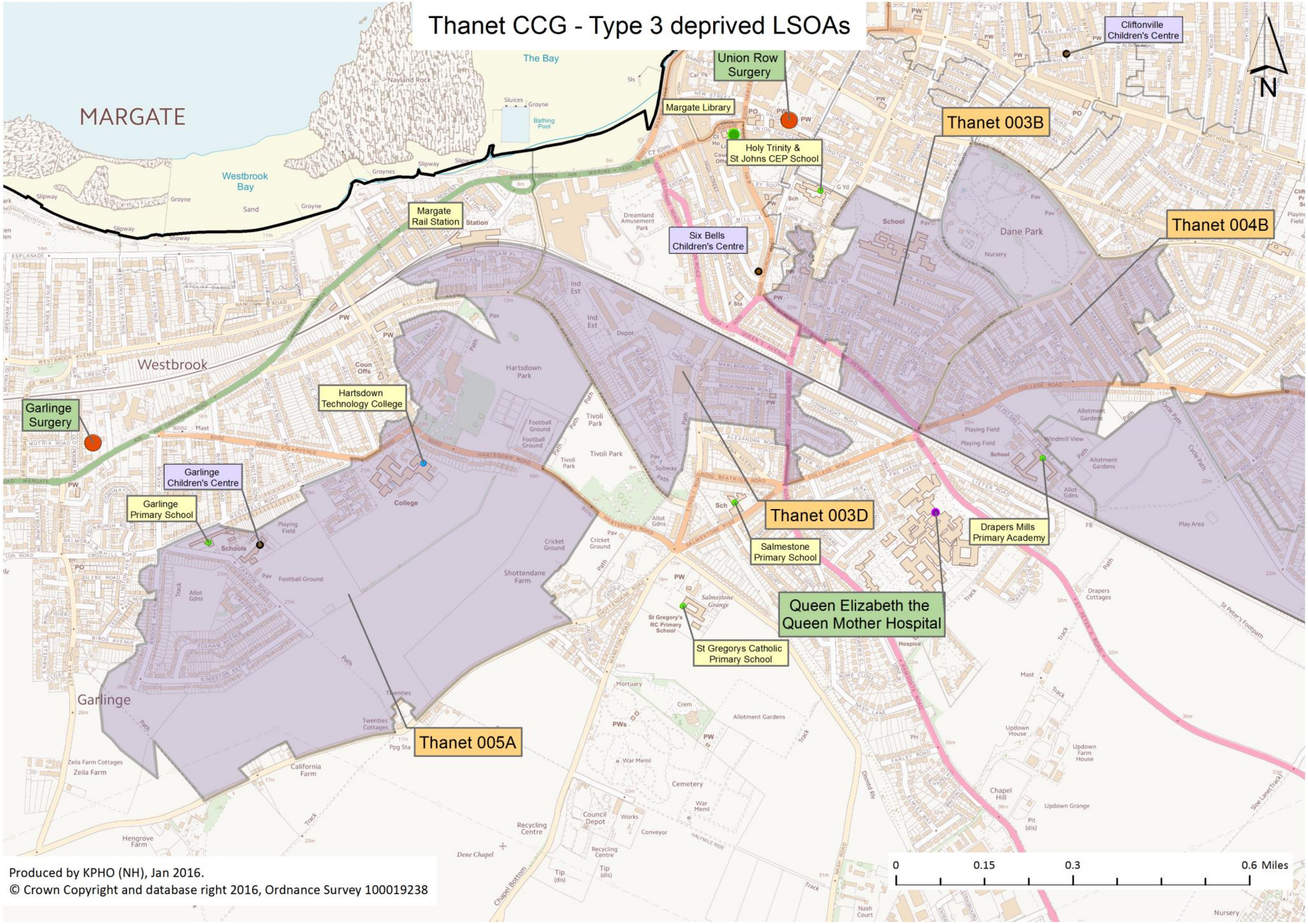


- Very high numbers of children
- Slightly lower numbers of over 50s

KEY FOCUS AREAS:

Training, qualifications and employment for parents

Child health and education



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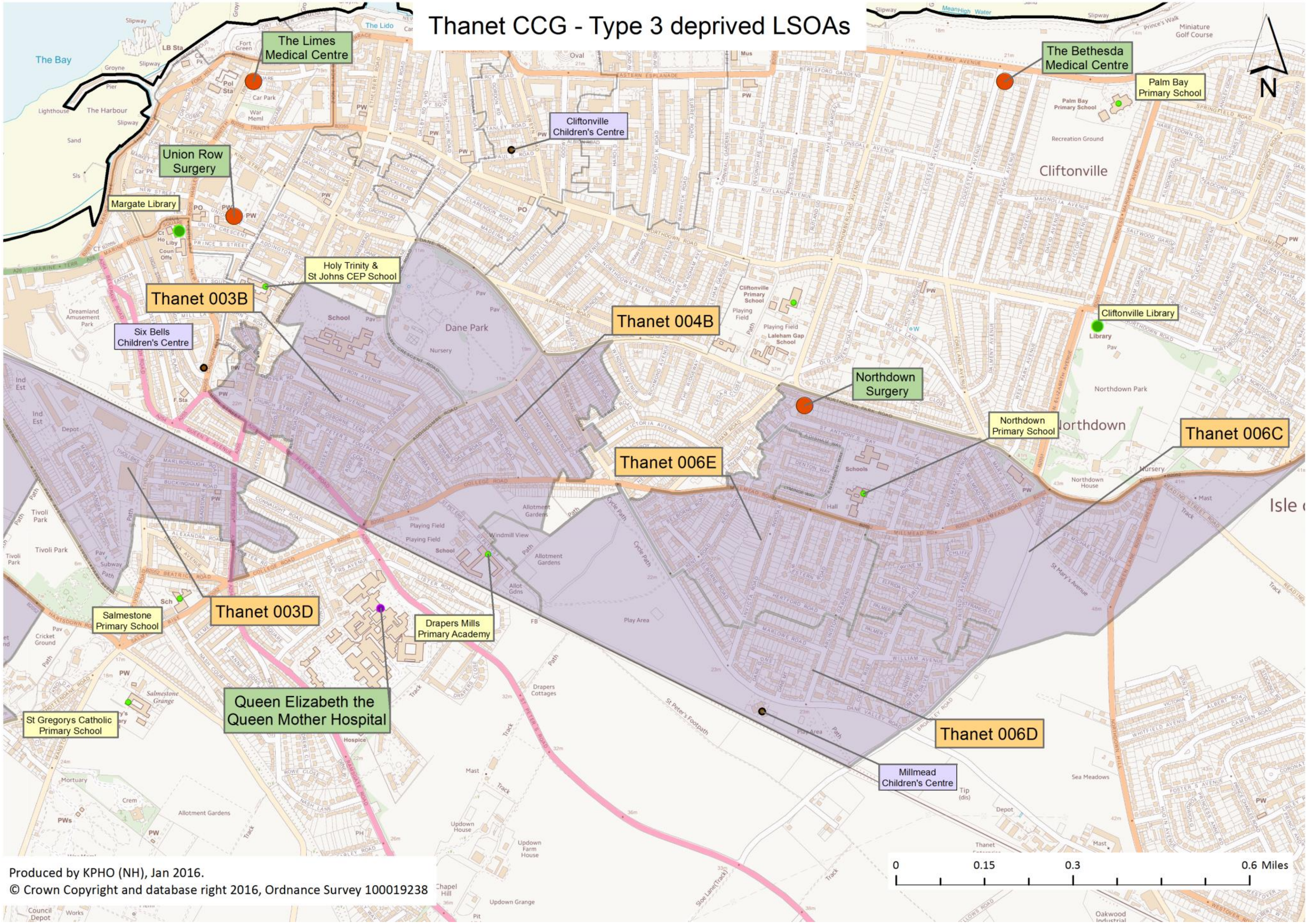
Thanet CCG - Type 3 deprived LSOAs



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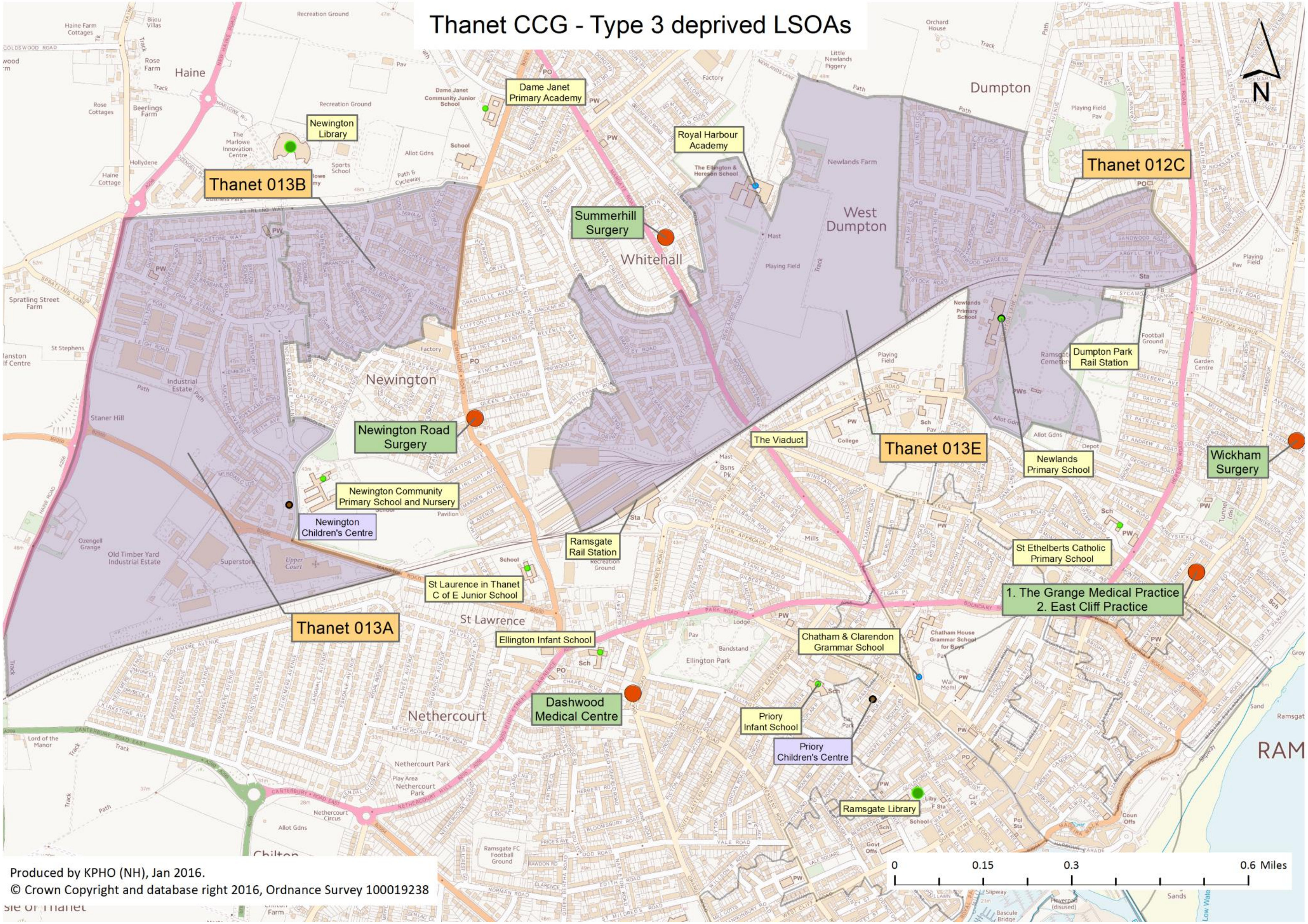
Thanet CCG - Type 3 deprived LSOAs



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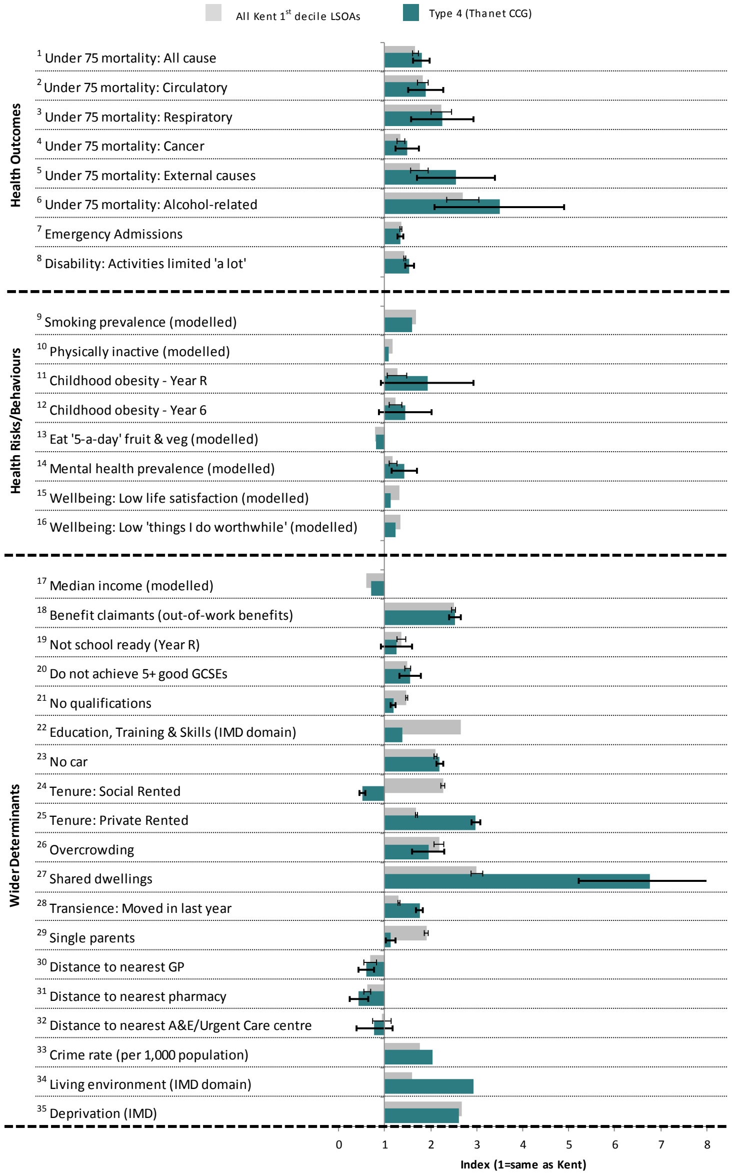
Young people in poor quality accommodation

Thanet CCG
Type 4 Deprived LSOAs
Central Harbour, Westbrook, Eastcliff, Clinftonville West



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MAIN ISSUES

Characteristics

- Young adults in private rented accommodation
- High levels of shared dwellings and overcrowding
- Better educated than the other deprivation types
- Particularly poor living environment with high crime rates
- Low incomes, but not as low as other deprivation areas
- High levels of out-of-work benefit claimants, but not as high has Type I areas
- Particularly high levels of movement/ transiency

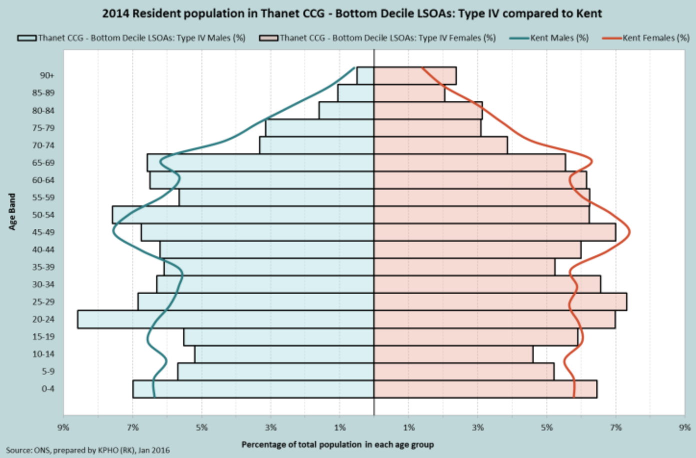
Health Risks/Behaviours

- High smoking prevalence

Health Outcomes

- High premature mortality rates
- High emergency hospital admission rates
- High rates of disability ('activities limited a lot')

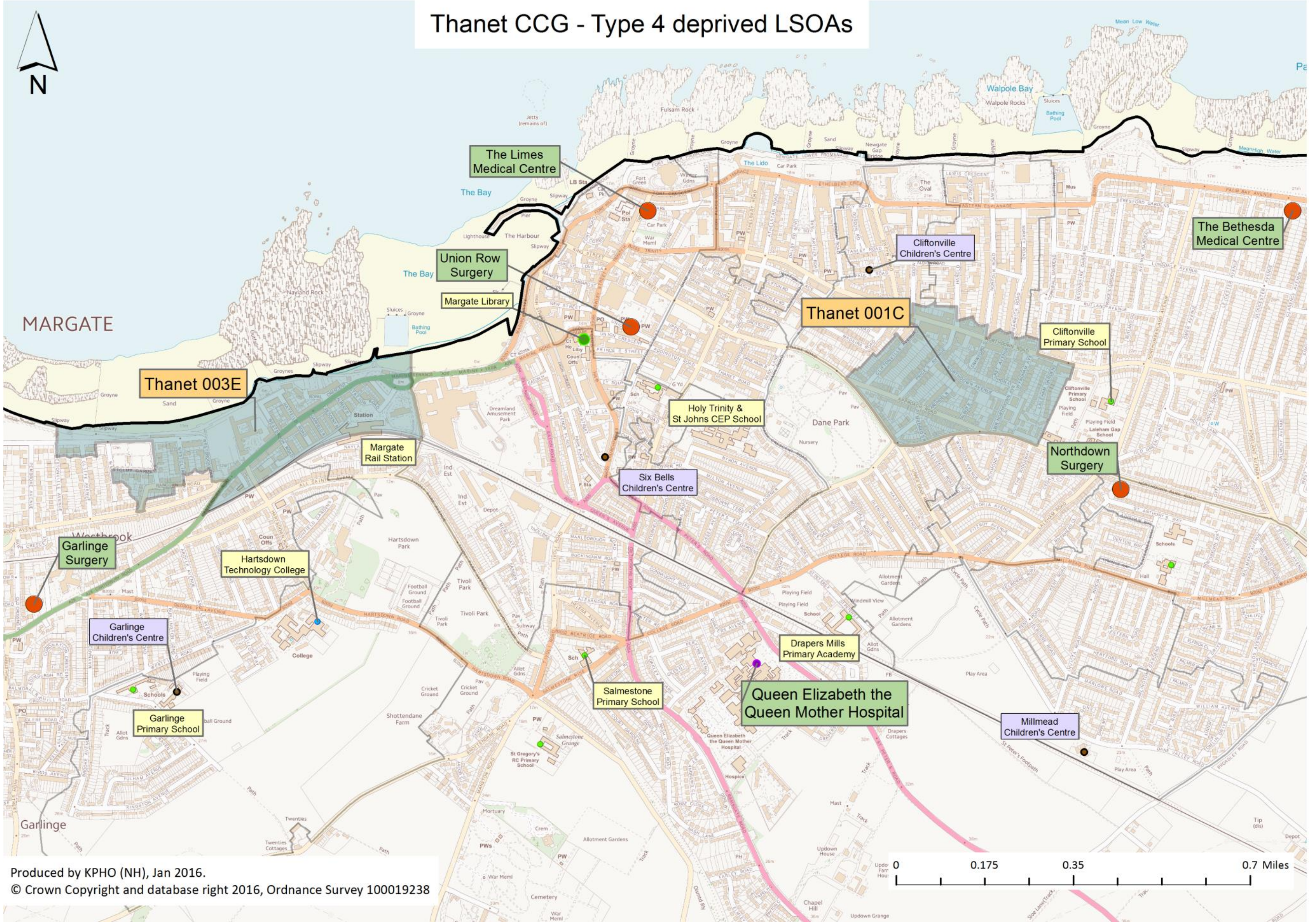
POPULATION DISTRIBUTION



- High numbers of young adults
- Low numbers of children and teenagers

KEY FOCUS AREAS:
Improve living environment and good affordable housing

Thanet CCG - Type 4 deprived LSOAs



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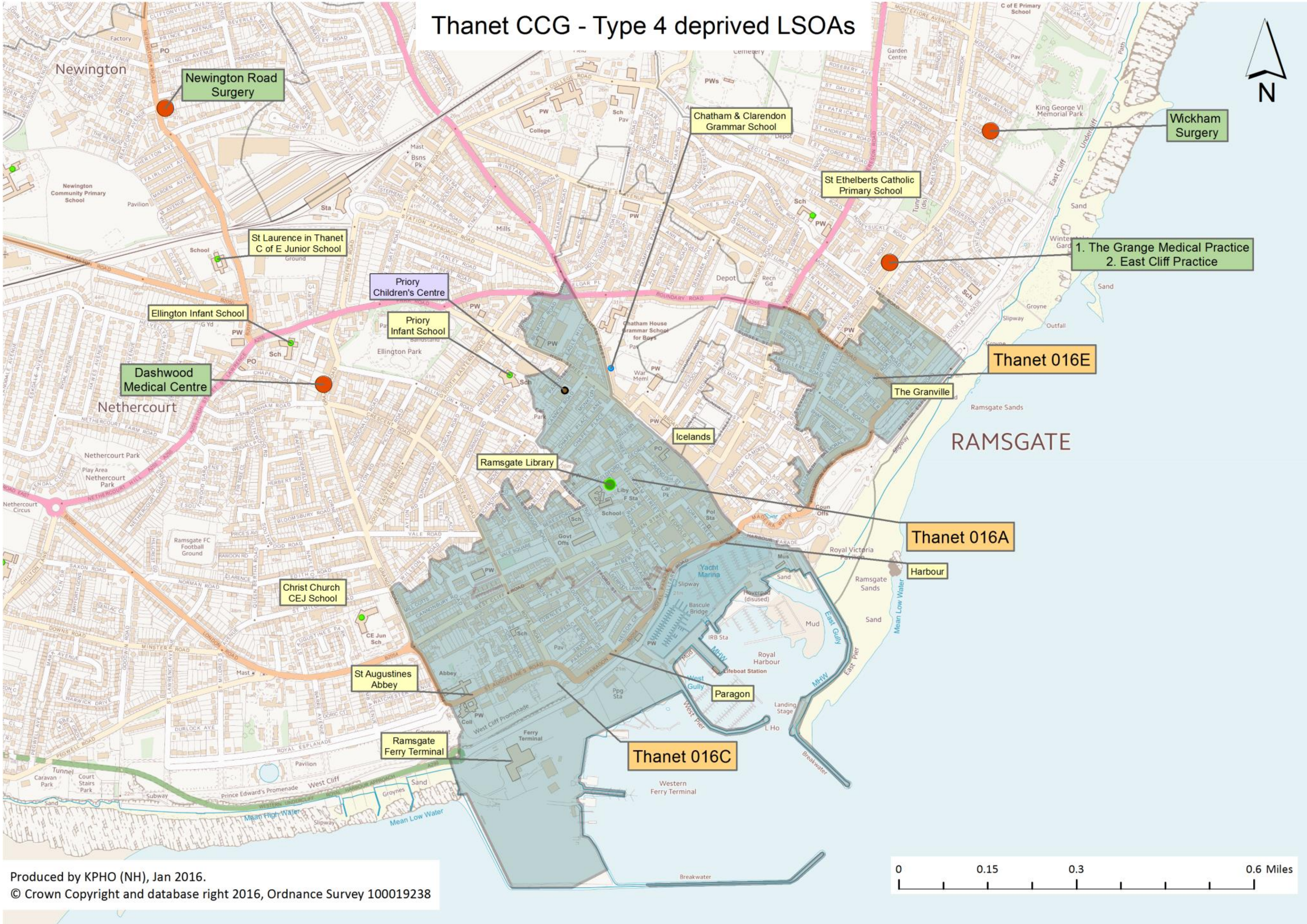
Thanet CCG - Type 4 deprived LSOAs
Newington Road Surgery
Chatham & Clarendon Grammar School
Wickham Surgery
St Ethelberts Catholic Primary School
St Laurence in Thanet C of E Junior School
1. The Grange Medical Practice
2. East Cliff Practice
Priory Children's Centre
Ellington Infant School
Priory Infant School
Thanet 016E
Dashwood Medical Centre
The Granville
Icelands
RAMSGATE
Ramsgate Library
Thanet 016A
Harbour
Christ Church CEJ School
St Augustines Abbey
Paragon
Ramsgate Ferry Terminal
Thanet 016C
Newington
Nethercourt
N
0
0.15
0.3
0.6 Miles
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GP Practices

GP Practices Serving Deprived LSOAs: Recorded Disease Prevalence

For the GP practices that serve LSOAs in the most deprived decile, we have analysed the recorded disease prevalence from QOF data (Quality Outcomes Framework). Note that the data shows recorded disease prevalence, and does not account for undiagnosed disease in the community.

- Generally high recorded prevalence of Chronic Kidney Disease, COPD, depression and mental illness.
- Summerhill Surgery, Garlinge Surgery and Northdown Surgery appear to have high recorded disease prevalence across a large number of conditions.

GP Practice		Asthma	Atrial Fibrillation	Cancer	Coronary Heart Disease	Chronic Kidney Disease	COPD	Diabetes	Heart Failure	Hyper-tension	Stroke & TIA	Mental health	Dementia	Epilepsy	Depression	Learning Disabilities
G82020	The Grange Practice	6.2	2.2	2.7	4.1	4.6	2.8	6.8	0.9	16.2	2.0	1.1	0.7	1.2	7.6	0.4
G82046	Summerhill Surgery	7.2	2.0	3.7	4.2	8.7	4.7	8.1	1.0	19.9	1.9	1.1	0.6	1.0	13.3	0.7
G82052	The Limes Medical Centre	8.0	1.5	2.0	2.8	4.6	3.1	7.5	0.7	15.6	2.0	1.4	0.5	1.0	14.9	0.5
G82064	Dashwood Medical Centre	5.3	1.6	2.7	2.9	6.1	2.4	6.0	0.7	16.3	1.7	1.2	0.4	1.0	10.0	0.5
G82066	Northdown Surgery	6.3	2.2	2.7	3.5	6.2	3.2	7.7	1.0	15.9	2.1	1.3	0.9	1.1	9.9	1.2
G82105	The Bethesda Medical Centre	4.6	2.0	2.1	3.8	5.4	2.1	7.4	0.7	13.5	2.0	1.2	1.4	1.0	5.8	0.5
G82126	East Cliff Medical Practice	6.6	2.0	2.7	3.7	6.8	2.6	6.8	0.5	16.2	2.0	0.9	0.7	0.8	11.3	0.9
G82150	Newington Road Surgery	5.5	1.3	1.7	2.7	7.3	3.4	7.6	0.8	15.7	1.3	0.7	0.6	0.8	11.9	0.2
G82649	Union Row Surgery	4.8	1.0	1.7	2.5	2.6	4.3	5.4	0.6	9.3	1.5	0.9	0.2	0.8	7.5	1.1
G82810	Garlinge Surgery	5.4	1.7	1.9	4.1	8.5	3.2	8.2	1.1	16.3	1.6	1.5	0.9	0.7	9.8	1.0

Denotes value is in the upper quartile for GP practices in Kent   Denotes value is in the lower quartile for GP practices in Kent

Figures for chronic kidney disease (CKD), epilepsy and depression related to patients aged 18+, figures for diabetes to patients aged 17+. Other measures (including learning disability) related to all ages

Source: HSCIC - Quality and Outcomes Framework (QOF) for April 2014 - March 2015, prepared by KPHO (RK), December 2015

Data Sources

1-6 Age-standardised mortality rates, 2006-2014. Source: PCMD. **2** ICD10: I00-I99. **3** ICD10: J00-J99. **4** ICD10: C00-C97. **5** ICD10: U00-Y99. **6** ICD10: F10, G31.2, G62.1, I42.6, K29.2, K70, K73, K74, K86.0, X45, X65, Y15.

7 Emergency admissions, 2012/13-2013/14. Source: SUS.

8 % self-reporting day-to-day activities 'limited a lot', 2011. Source: Census.

9 Modelled based on smoking prevalence data by Mosaic type. Source: Experian (TGI: 'Heavy', 'Medium' & 'Light' smokers combined).

10 Modelled based on % who do not exercise by Mosaic type. Source: Experian (TGI).

11-12 % children measured who were obese, 2013/14. Source: NCMP.

13 Modelled based on % who claim to eat '5-a-day' fruit and vegetables by Mosaic type. Source: Experian (TGI).

14 Modelled mental health prevalence based on GP practice-level data, 2014/15. Source: QOF.

15-16 Modelled wellbeing based on ONS Annual Population Survey (APS) data by Acorn type, 2011/12. Source: DCLG. **15** % scoring 0-6 for 'Overall, how satisfied are you with your life nowadays?' **16** % scoring 0-6 for 'Overall, to what extent do you feel the things you do in your life are worthwhile?'

17 Modelled based on median household income data by Mosaic type. Source: Experian (ConsumerView).

18 % claiming out of work benefits (defined as all those aged 16-64 who are jobseekers, claiming ESA & incapacity benefits, lone parents claiming Income Support and others on income related benefits), February 2015. Source: DWP (from Nomis).

19 % Year R pupils not achieving a good level of development, 2015. Source: KCC, MIU.

20 % pupils not achieving 5+ A*-C GCSEs (including English & Maths) at the end of Key Stage 4, 2015. Source: KCC, MIU.

21 % with no qualifications (based on persons aged 16+), 2011. Source: Census.

22 Education, Training & Skills IMD domain (average score), 2015. Source: DCLG.

23 % of households with no car or van, 2011. Source: Census.

24 % of households living in social rented accommodation, 2011. Source: Census.

25 % of households living in private rented accommodation, 2011. Source: Census.

26 % of households with an occupancy rating of -2 (i.e. with 2 too few rooms), 2011. Source: Census.

27 % of households with accommodation type 'shared dwellings', 2011. Source: Census.

28 % of households not living at the same address a year ago, 2011. Source: Census. Please note that OAs E00124937 & E00166800 have been removed from this analysis due to the undue influence of Eastchurch prison on levels of transience.

29 % of households with no adults or one adult and one or more children, 2011. Source: Census.

30-32 Distance to nearest GP/pharmacy/A&E or Urgent Care centre (in miles, as the crow flies from population weighted centroid of LSOA), 2015. Source: KCC Business Intelligence.

33 Crime rate (recorded crime per 1,000 population), Oct 2013 - Sept 2015. Source: data.police.uk.

34 Living Environment IMD domain (average score), 2015. Source: DCLG.

35 Index of Multiple Deprivation (IMD) (average score), 2015. Source: DCLG.

inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 6.3

THE MUNICH AIRPORT NOISE STUDY - EFFECTS OF CHRONIC AIRCRAFT NOISE ON CHILDREN'S PERCEPTION AND COGNITION

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Keywords:
AIRCRAFT NOISE, COGNITION, CHILDREN, PERCEPTION

ABSTRACT
Before the opening of the new Munich International Airport in May 1992 and the close down of the old airport, children at both sites were recruited into aircraft noise groups (aircraft noise at present or to come) and matched control groups with little aircraft noise. A total of 327 children took part in one data collection wave before and two waves after the switch over of airports. A number of physiological and psychological tests were performed at each wave. Among the perceptual and cognitive tasks, long-term memory and mastery of a difficult German word list was impaired in the aircraft noise group at the new airport, and was improved in the formerly noise exposed group at the old airport. Running memory improved after the old airport was closed. At the new airport, ratings of annoyance remained at a higher level for the experimental group, as did the signal-to-noise ratios in a listening task.

1 - INTRODUCTION AND METHOD

The shutdown of the former Munich International Airport in May 1992 and the inauguration of the current one at the same time have provided an unprecedented opportunity to investigate in a longitudinal, prospective design the psycho-physiological, perceptual cognitive, motivational, and quality of life effects of noise exposure on children. The broad, long-term objective of this research program is to understand how chronic environmental stress from aircraft noise affects children.

Beginning in the fall of 1991, before the change over of airports, children at both sites were recruited into experimental and control groups. The two experimental groups were comprised of the children at the old airport that were exposed to high levels of aircraft noise, and the children who were to be so exposed at the new airport. The two control groups were selected from areas that were not or would not be exposed to much aircraft noise. The control groups were matched with their respective experimental groups on the basis of sociodemographic characteristics. One wave of data collection occurred prior to the change over of airports, the second wave one year later, and the third wave two years later. The children were aged 9-12 years when the study started. Three hundred twenty-seven children took part in all three measurement waves. At each wave they were tested individually in silence for 1.5 hr on two consecutive day in a specially designed air-conditioned and sound-attenuated trailer. The trailer has four closed booths that accommodate a child and an experimenter.

In the present paper longitudinal results from the set of perceptual and cognitive tasks will be presented. For other results and more details about the study, see [1] and [2].

All children went through a simplified audiometric screening task, run from a computer based device. Annoyance ratings were established by training the children to use a magnitude estimation procedure, by first jumping outside the trailer (max, 50%, 25% etc.) and to "jump" with their fingers on a 200 mm

scale when later presented with three replications of three kinds of sounds (broadband, aircraft, road traffic) at five sound levels (42-90 dBA L_{eq}).
A computer controlled signal-to-noise task was designed to assess speech discrimination against different noise backgrounds. A passage of a story was first read from a tape-recorder against a silent background and the children were instructed to choose a comfortable listening sound-level by pushing "+" and "−" buttons. The level chosen defined the L_{eq}-level at which segments of non-fluctuating pink-like broadband noise, and fluctuating aircraft and road noise were subsequently played in the background. In the foreground the story was heard, the sound-level of which dropping randomly by 10 dBA. The children were instructed to readjust the level of the voice after the drops with the + and − buttons, to the subjective criterion that they could understand what was said if they concentrated.
In the reaction time task, random sequences of red and green lights were to be responded by pressing one or the other of two buttons. Two 5 min. sessions were run with each child. The first session was in silence and the second one in 85 dBA L_{eq} fluctuating aircraft noise.
The running memory task consisted of strings of consonants presented over headphones at the rate of one per second. Randomly, the sequence was stopped and the children were asked to recall as many consonants as they could in the correct position.
An easy version of an embedded figures' task [3] was used. The children were presented a page with twelve complex figures. On the top, five simple figures were presented, and the task was to pick out which one of the five simple figures were embedded in the complex ones.
Long-term recall tests with scoring manuals were developed for each measurement wave. On the first day the children read the text in intermittent noise and on the second day two they were tested in silence for recall with open-ended questions. This test was adapted from Hygge [4], who reported impairment of one week long-term recall in children exposed to 15 min acute aircraft and road noise.
A standardized German reading test [5] was used. The children read paragraphs and word lists of increasing difficulty. Errors and speed were scored.

2 - RESULTS

Audiometric screening did not indicate any impairments as a result of aircraft noise exposure.
The results for the long-term memory task and the difficult part of the German word list were very similar. See Fig. 1 for the long-term memory data. An initially poorer performance in the aircraft noise exposed children at the old airport, develops into a negligible difference between the groups in wave 3. At the new airport, an initially negligible difference between the groups developed into significantly poorer performance in the aircraft noise exposed group at wave 3.
For the difficult sections of the German reading task there were trends similar to that of the difficult word list, but they did not pass the statistical significance tests.

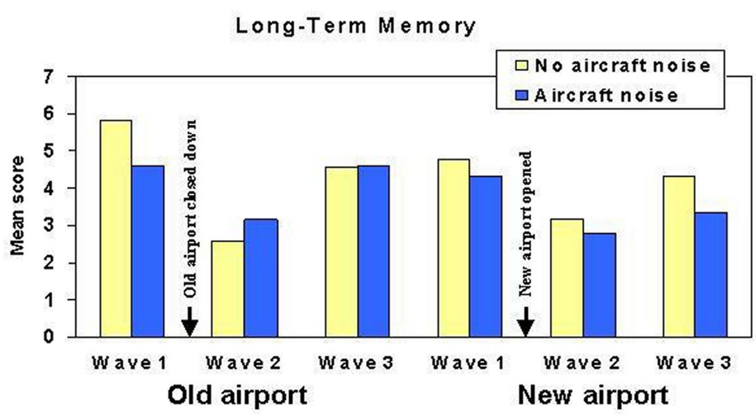

Figure 1: Long-term memory.

In the running memory task, see Fig. 2, the results from the old airport showed recovery from a somewhat poorer performance in the aircraft noise group to the level of the control group in wave 3. At the new airport, the introduction of the aircraft noise after wave 1 did not significantly affect performance.
For the embedded figures task and for the reaction time task there were no significant interactions involving aircraft noise exposure and data collection wave.
Auditory discrimination against different noise backgrounds, in the signal-to-noise task, indicated improvement with age at the old airport, but no differential improvement between the groups. See Fig.

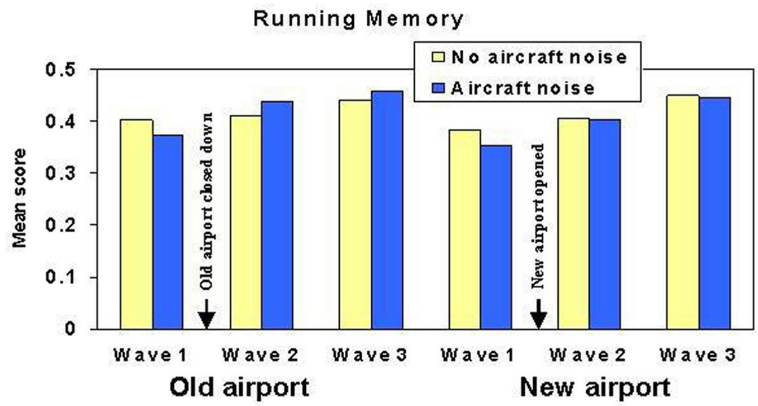

Figure 2: Running memory.

3. (For the signal-to-noise task no data are given for Wave 2 due to apparatus failure). At the new airport, the aircraft noise seems to block the improvement in auditory discrimination that comes with age. The were no significant interactions involving aircraft noise exposure and type of background noise (broadband, aircraft, road traffic).

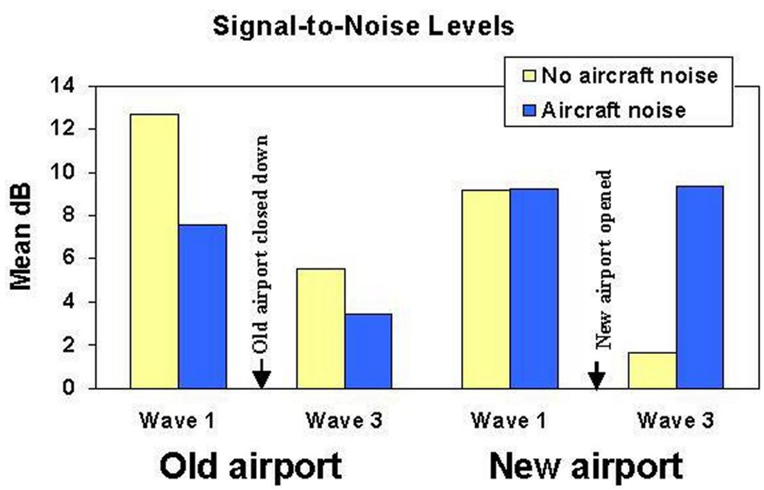

Figure 3: Signal-to-noise levels.

The type of the noise (broadband, aircraft and road traffic noise) played some role in the development of annoyance ratings across measurement waves. At the new airport, there was more of a gradual decline in the ratings of the loudest sounds for the broadband and road traffic noise in the control group than in the experimental group. At the old airport, there were no significant interactions involving aircraft noise exposure and data collection wave. Master scaling (calibrating each individual against the group mean and variation) of the annoyance ratings did not basically change the result pattern.

3 - CONCLUSIONS

Two of the cognitive tasks, recall and language mastery, showed the doubly replicated aircraft noise effect of disappearing when the old airport was closed down and coming forth when the new airport started to operate. This is a very strong empirical foundation for the conclusion that cognitive tasks requiring central language processing are particularly sensitive to noise. For the age span studied (9-12 years) these effects were reversible but of course we don't know how much of the reversibility is locked that age group.

Other cognitive and perceptual measures showed show some, but not double effects of the chronic aircraft noise exposure. Memory span in running memory improved when the old airport closed down. Improvement with age in the auditory discrimination task (signal-to-noise) was delayed in the exposed children at the new airport. Declines with age of annoyance ratings were held back in the same group.

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Journal of Child & Adolescent Behavior

Kamp, et al., J Child Adolesc Behav 2015, 3:1
DOI: 10.4172/2375-4494.1000179

Research Article Open Access

The Effects of Noise Disturbed Sleep in Children on Cognitive Development and Long Term Health

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Abstract

Undisturbed sleep is essential for physiological and psychological health. Children have a special need for uninterrupted sleep for growth and cognitive development. Noise is an environmental factor that affects most children, but the knowledge of how children's health, wellbeing and cognitive development are affected by noise disturbed sleep due to road traffic is very incomplete. It has been shown that although children are less likely to wake up or react with sleep cycle shifts due to nighttime exposure, they might be more likely to react with physiological effects such as blood pressure reactions and related motility during sleep. The aim of this paper is to formulate a set of hypotheses as a base for future studies into the short and long term effects of noise induced sleep deprivation on health and child development and how this effects health and wellbeing later on in life. Because the literature is still trying to understand the nature of sleep disturbance among children in general a scoping review was used to achieve this, combining conceptual issues with a description of the scarce literature on noise and sleep disturbance in children as example. Based on this a set of hypotheses was formulated. It is concluded that future studies into the health effect of environmental noise exposure in early life should address these potential hypotheses and mechanisms and pay specific attention to the mediating role of sleep related aspects, including noise in conjunction with other environmental exposures such as indoor climate and exposure to sounds and light from electronic devices.

Keywords: Sleep; Children; Noise; Cognitive development; Health

Introduction

In the recently published guideline by the WHO [1] for the burden of disease from environmental noise and elsewhere [2] it is concluded that future epidemiological noise research will need to focus on vulnerable groups; some noise exposures may be worse for particular subgroups than for others such as children, older people and lower socioeconomic groups. This conclusion supports the notion that noise effects can and should be differentiated between subgroups. In most recent reviews on noise and health, this topic has been touched upon, but evidence is still scarce and scattered. A recent review [3] identified thirty seven papers (2007-2011) pertaining to primary school children, two to preschool children and four to neonates. Four papers address effects of noise in specific patient groups such as children with autism, asthma and Attention Deficit Hyperactivity Disorder (ADHD) Health effects most frequently described in the literature are annoyance, sleep disturbance, cardiovascular disease, cognitive effects and effects on hearing. Knowledge of how cognitive and long term health effects are mediated by noise disturbed sleep is very incomplete. It is generally accepted that undisturbed sleep is essential for physiological and psychological health. Children have a special need for uninterrupted sleep for growth and cognitive development. Environmental noise is a well-known factor to disturb sleep and it can be assumed to affect most children living in urbanized areas. In addition to noise in schools and preschools, many children are exposed to potentially disturbing traffic related noise at night. One of the most serious effects of community noise is sleep disturbance [4]. In this paper we are particularly interested in the role of sleep disturbance in cognitive development and cardiovascular effects in children and the (health) effects of childhood noise exposure and sleep disturbance later on in life. The aim of this narrative review is to formulate a set of hypotheses as a base for future studies into the effects of noise induced sleep deprivation on health and child development. Although we are aware that environmental noise is only one of the causes of childhood sleep disturbance we want to draw attention to this understudied and increasing problem, while at the same time placing the issue in a broader context. After a general introduction on sleep and indicators of sleep disturbance, in adults and children existing evidence in children is described in terms of prevalence and effects moving from acute biological effects, day after effects on performance and cognition to more chronic effects of sleep disturbance on health, wellbeing and cognitive impacts later on in life. The possible mechanisms are described and a set of hypotheses is formulated.

A conceptual model

It has been shown that nighttime noise can negatively affect people's sleep. The relationship between environmental noise and different aspects of sleep, and long term health effects, is a complex one. Several researchers have presented conceptual models to describe this complex interplay [5-7]. The model described by Porter et al. [5], which is presented below, can be considered as representative for current thinking about the mechanism by which environmental noise can lead to sleep disturbance and (long term) health effects. This model shows that noise can directly lead to acute effects and then through a chain of negative consequences to long term health consequences. Feedback mechanisms and modifying factors are hereby assumed, meaning that noise can lead to health consequences through indirect pathways. This complex web of interactions makes it difficult to quantify any simple exposure-response relationship between noise exposure and health effects.

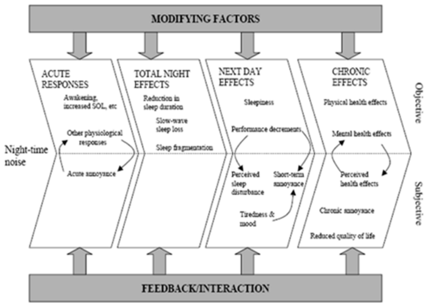

Figure 1: The conceptual model of noise and sleep of Porter et al. [4]

* SOL: Sleep Onset

The model distinguishes:

- acute responses that include immediate or direct disturbances caused by noise events,
- total night effects that are aggregations of (1) over the whole night,
- next day effects that are a result of (1) and (2), and
- chronic effects that are pervasive long-term consequences of (1,2) and (3).

Sleep disturbance is generally seen as an intermediate effect of noise and is assumed to be a potential initiator of diseases and/or a potential aggravator of existing disease. Whether this will happen depends on the person's vulnerability and/or sensitivity [8-11]. Potentially vulnerable groups are people with a somatic or mental disorder, shift workers and the elderly. Although some studies have shown that children are less likely to awake or to react with a shift in sleep cycles shifts, [12,13], there are indications that children are especially respond with stronger physiological effects during sleep such as blood pressure reactions than adults. [14-17]. However, in 2004 the Dutch Health Council [18] concluded that the strength of the evidence for children's sensitivity for acute cardiovascular effects in relation to noise disturbed sleep, is weak and even weaker for other biological responses. In general this conclusion still holds at this point in time: no additional evidence has accumulated on this since then.

Normal sleep in children

Sleep patterns can be described by ways of brain activity (electroencephalogram cq EEG), information about eye movement (electro-oculogram cq EOG) and muscle tone (electromyogram cq EMG). The sleep cycle contains two main states: rapid eye movement (REM) and non-rapid-eye movement (NREM), while NREM is subsequently separated into 3 sleep stages [18,19].

REM sleep features a low-amplitude, mixed frequency electroencephalogram EEG, with eye movements (EOG) showing bursts of REM activity similar to that seen during eyes-open wakefulness, and absent EMG activity due to brainstem-mediated muscle atonia that is characteristic of REM sleep. NREM (including slow wave) sleep is required for the brain to recover from fatigue, while REM sleep was for a long time considered as necessary for physical recovery and essential for the maintenance of quality sleep. Today there is no consensus on the exact relative functions of the various sleep stages for mental and physical health. Slow wave N3 stage sleep is generally considered to be important for physical restoration [20-22] and memory [23], while REM sleep is also believed to be important for cognition [24].

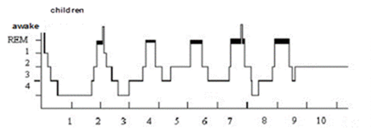

Figure 2: Time structure of a normal sleep pattern in children (source: Hofman [16])

Indicators of disturbed sleep

Sleep disturbance is a multi-faceted concept, referring to a broad range of effects from awakening to subtle changes in autonomic physiology, and these changes are not necessarily consistent within an individual for a given level of noise stimulus as there are complex patterns of neurophysiology associated with the different EEG defined sleep stages and the time of night. Given this complex process there are various end-points that can be chosen to assess the degree of sleep disturbance These range from measures extracted from the EEG based polysomnography, which is considered the 'gold-standard' of sleep recording and provides a direct measure of cerebral activity from which a number of macro and microstructural features can be extracted. [15] Sleep disturbance also refers to subjective effects such as perceived quality of sleep or nighttime annoyance.

As a consequence, many different methods and techniques are used to investigate the possible effects of noise on sleep disturbance which vary widely depending on the responses/effects being studied (see the model of Porter in figure 1). These methods can roughly be divided into two categories: physiological measures and self-report measures such as diaries and questionnaires.

Table 1 gives an overview of physiological parameters, the underlying concept and their operationalization.

Type of examination	Indicator for	What is examined?
Electroencephalograph (EEG)1)	The sleep stages	Total sleep time, total time spent overnight in Slow Wave Sleep(SWS; deeper sleep) and in the stage of Rapid Eye Movement (REM; dream sleep)
EMG1 EOG1 Electrocardiography (ECG) Plethysmography Actimetry	Muscle tone Eye-movements Cardiac function Heart rate and blood pressure Motility	Heart rate Total sleep time, time of falling asleep, wake-up time, Number of awakenings
Overnight cortisol in blood or fluvia Overnight urinary catecholamine	Level of circulating catecholamine Level of total catecholamine released during sleep, not taken up by sympathetic nerve endings	Sympathetic nervous activity

Table 1: Overview of physiologic examinations used in studies investigating the possible effects of noise on sleep. (Source: van Kempen, Staatsen, and van Kamp, 2005 [25])

1The measurement of brain activity by means of EEG, EMG and EOG is also called polysomnography.

As Table 1 shows, awakenings can be measured and defined in several ways. A distinction is made between arousals (or EEG awakenings) and behavioral awakenings. An arousal is defined as an EEG response that has all the characteristics of an individual awake; behavioral awakening is confined to a verbal or motor response, indicating the subject is awake.

Indicators used in child studies

Sleep studies in children using these different methods described above are rare and even more so are studies into the effect on sleep due to noise exposure. In 2004 a committee of the NL Health Council [18] concluded that very little is known about the biological effects on children of exposure to noise when sleeping, or about the impact on children's health and well-being and this conclusion still holds today. Although the findings of the European research project Road traffic and Aircraft Noise exposure and children's cognition and Health (RANCH) and the Munich study [26,27] have shed some light on the effects of noise on children as compared to their parents, there is still an overall lack of knowledge regarding the issue of childhood exposure to noise when sleeping. During a noise-disturbed night, effects might show at different stages, e.g. the sleep onset might be slightly delayed or while REM sleep might still shows clear rhythmic occurrence, some of its episodes might be fragmented. Also significant awakenings might occur throughout the sleep process and overall sleep efficiency is reduced as was shown by Muzet [14] in a hypnogram of a young adult during a noise disturbed sleep, as compared to a normal night. To our knowledge no such example is available for children. More objective measures of after effects include excretion of hormones, sleepiness, task performance tests, and cognitive functioning tests.

After effects (non-acute) are usually measured subjectively using questionnaires on sleep quality, tiredness, and annoyance. Subjective measures are rarely applied to children. One of the few exceptions is the study of Öhrström et al. [13] among 9-12 year old children exposed to road traffic noise in their home, in which both the parents and children were asked to rate their overall sleep quality, frequency of movement and extent of sleepiness when waking up on an 11 point scale.

Methods

In view of the main aim of this paper to formulate a set of hypotheses regarding the short and long term effects of sleep disturbance in children, this paper combines a conceptual approach with a more narrative review method, which both build on the work we have previously performed in the field of noise and sleep disturbance in adults and children. Primarily, previous reviews on the topic have been used as a basis as well as a systematic review on the association between environmental noise and sleep disturbance performed for the EPD Hong Kong [3a] and an ICBEN review on health effects of noise in vulnerable groups [3]. More recent literature on the topic was sought making use of the major literature data bases (MEDLINE, PUBMED, SCOPUS and GOOGLE SCHOLAR). Since the current literature is still trying to understand the mechanisms and meaning of sleep disturbance in children it is still too early for a proper systematic review on this topic.

Results

Prevalence

Estimates of the prevalence of sleep disorders in children vary on average between 10% to 25% [28,29]. In a large epidemiological study in the USA based on general practitioner (GP) registry data and using the ICD-9 sleep diagnoses, Meltzer et al. [30] found much lower figures with prevalence in the range of 3-5%. This might be indicative of underreporting by GP's, as the authors suggest, but more likely these low prevalence rates are associated with the way sleep disturbance was defined. The GP registry data seem to only 'catch' the more serious and chronic forms of disturbance; milder cases of child's sleep disturbance are not per se reported to the GP's by the parents. Comparable rates were reported by Rona et al. [31], based on a large epidemiological study in English and Scottish children which found that 4% of the 14 372 children experienced sleep disturbances at least once a week. Important risk factors identified were socioeconomic factors associated with ethnicity and respiratory illness. In 1999 Thunström [32] found in Sweden that 16% of the parents of children aged 6 to 18 months reported moderate to severe problems with falling asleep and up to 30% frequent awakenings per night. Parental worry and anxiety were found to be the most common causes of the child's sleeping problems. In 6% of the children severe sleep disorders as defined by the ICSD were diagnosed. A Finnish study performed in 2000 [33] among a sample of 8 to 9 year old schoolchildren estimated the prevalence of sleep problems by asking the children as well as the parents. Disturbed sleep was reported by 22% of the parents and 18% of the children. Remarkable was that these did not always overlap and adding both resulted in an estimate of 32%, concerning mild cases. In less than 0.5 % the problems were serious. It was concluded that sleep problems are often overlooked by parents and therefor parents as well as the children should be asked to provide information.

A Swedish survey at the national level [34] performed in 2005 reports that one out of seven 12-year-old children (15%) indicated themselves that any noise prevented them from falling asleep. For about 25,000 schoolchildren aged 7-14 years this occurred several times a week. Approximately half of these children state that several times a week they had difficulties to sleep the whole night without waking up. There are only a few examples of studies of how children are affected by sleep due to road traffic noise [17].

Evidence for noise disturbed sleep in children

The Night Noise Guidelines of WHO [17] concluded that children with disturbed sleep present cognitive dysfunction and behavioral disturbances, abnormal growth hormone release, increase of diastolic BP and an increased risk of accidents and use of sleeping pills. These effects form a mix of acute, next day and long term outcomes and are primarily based on older studies from before 1990 in specific patient groups. Below more recent evidence on the effect on environmental noise on children's sleep per outcome category is summarized.

Acute effects and effects over a night

The Health Council Netherlands [18] made the following distinction of effect within the category of acute effects of noise on sleep: Heart rate acceleration, a change in the quantity of a stress hormone, sleep stage changes (EEG), EEG awakening, motility and motility onset and finally behavioral awakening (self-indicated/registered). Because of the lack of research data on children, it is not possible to say with confidence whether children are more reactive than adults to other acute biological responses.

Next day effects

A study of 9-12 year olds in the EU project RANCH showed that children's problems with daytime sleepiness was higher with increasing road traffic noise exposure levels outside the children's home. [13] Sadeh et al. [35] found an association between poor sleep quality and worsened performance on complex cognitive tasks in school related to difficulty in sustaining attention. A sub-study [26] on aircraft noise at night in RANCH found no effect on children's reading comprehension or memory in addition to the effect of aircraft noise during daytime. However, the aircraft noise exposure during the day at school and at night at home were so strongly correlated that the variation was insufficient to test whether day time noise at school and night noise at home had independent effects.

Regarding cognitive after effects of sleep deprivation, Hygge et al. [27] (see also WHO background paper NNGL) deduced that noise in the early night, e.g. aircraft noise before midnight, could be particularly damaging to memory and related cognitive functions. Although these effects have been found in adults, this implication has not yet been explicitly tested in children. At the moment it is known that sleep affects memory, but not clear is how. New evidence primarily based on adult studies points in the direction of an increased effect on memory due to noise in the early night, but there is as yet no graded quantification about whether ordinary before-midnight noise levels around large airports are sufficient to make a difference. Further, since children's memory systems pass through developmental changes and are not structured in the same way as in adults, it would be interesting to know to what extent the results found for adults are also valid for children, and whether the depth of children's sleep counteract or enhance the slow wave sleep (SWS) dominance in the early night. An important conclusion is that studies into the cognitive effects of daytime noise levels cannot be used as a proxy for effects of night time exposure. Wilhelm et al. [36] studied the beneficial effects of sleep on retention of declarative memories and concluded that this was comparable to results in adults. Children showed smaller improvement in finger-tapping skill across retention sleep than wakefulness, indicating that sleep-dependent procedural memory consolidation depends on developmental stage. Secondary analysis of two large airport data [26] showed that nighttime aircraft noise exposure has no additional impact on reading or recognition memory beyond the effects of daytime noise exposure. It also showed no effects of nighttime noise exposure on self-rated health or overall mental health. Effects on motivation and further studies into the restorative function of sleep [37] are brought forward as important topics for future studies. Healthy normal children with fragmented sleep (measured by actigraphy) also showed lower performance on neurobehavioral functioning (NBF) measures, particularly those associated with more complex tasks, and also had higher rates of behavioral problems. [38] In normal children without sleep disorders, modest sleep restriction was found to affect children's neuro-behavioral functioning (NBF). Sadeh et al. [39] monitored 77 children for 5 nights with activity monitors. On the third evening, the children were asked to extend or restrict their sleep by an hour on the following three nights. Their NBF was reassessed on the sixth day following the experimental sleep manipulation and this showed that extended sleep led to improved sleep quality and sleep restriction led to a reduction in self-reported alertness.

Long term health effect of disturbed sleep

Long term health effects of disturbed sleep have been studied primarily in adults. In general we still lack evidence regarding the long term effects of instantaneous sleep-disturbances, but more recently there is evidence of increased risk for several diseases in adults. For example there is increasing evidence that chronic sleep deprivation and cardiovascular disease are associated. Non night-time dipping effect DBP as indicator of a lack of restoration has lately received more attention; in a study on a sub-sample of the EU HYENA project (N=149) a non-dipping effect of diastolic BP (blood pressure)at night was found in the noise exposed group, which has previously been identified as independent risk factor for CVD (cardiovascular disease) [41]. Patients with chronic insomnia show a disturbed balance in their immune system [42,43]. Circadian disorganization in relation to sleep deprivation may also be important: changed body metabolism and potential effects on obesity showed in a study of Taheri [44,45] that an imbalance between leptin and ghrelin can lead to an increased sense of hunger with weight gain as a consequence. Obesity in its own turn is a risk factor for cardiovascular disease and diabetes, by creating a disturbance of the glucose metabolism [46]. Also the risk of diabetes due to sleep disturbance [53] and poorer cognitive performance [30,47] have been identified as accompanying long term effects of disturbed circadian rhythms.

Important finding on the relation between (noise-related) insomnia and mental health, reported in the background paper of Stansfeld for the WHO NNGL, is that insomnia more often precedes rather than follows incident cases of a mood disorders [42]. Compared to good sleepers, severe insomniacs reported more medical problems, had more physician-office visits, were hospitalized twice as often, and used more medication. Severe insomniacs had a higher rate of absenteeism, missing work twice as often as did good sleepers. They also had more problems at work including decreased concentration, difficulty performing duties, and more work-related accidents [43]. It is concluded that evidence regarding the role of noise exposure, sleep and the development of depression, is still scarce.

Studies on long term health effects due to noise disturbed children are practically rare. It has been put forward that an elevated BP during childhood might be a good predictor of hypertension later on in life [40]. However, secondary analysis of two large airport data on the health effects of noise in children (aged 9-11) [26] showed that nighttime aircraft noise exposure had no additional impact on self-rated health or overall mental health in schoolchildren. Longitudinal studies are urgently needed in order to evaluate long term consequences of a disturbed sleep.

Cardiovascular effects of noise and the role of sleep disturbance

Only a few epidemiological studies exist about how long term nocturnal noise exposure affects cardiovascular health/outcomes. An exception is a study of Maschke et al. [48], the results of which suggested slightly higher effect estimates (odds ratio 1.9 vs. 1.5) for the prevalence of hypertension in adults with respect to the noise exposure of the bedroom (during the night) compared with the exposure of the living room (during the day). Critique on these findings is directed at the composition of the sample (older and health conscious group). There is some new evidence that the association between annoyance and CVD outcomes is stronger for sleep related annoyance/ disturbance. [40,49,50] Sleeping behavior such as closing windows, moving to another room are assumed to play a mediating role in this association.

As for children, analysis on the pooled data set (Heathrow, Schiphol) of the RANCH study [51] indicated that aircraft noise exposure at school was related to a statistically non-significant increase in BP and heart rate in children. Road traffic noise showed an unexplained negative effect. Significant associations with night-time exposure were found and based on this it is concluded that blood pressure elevations might also be seen as an effect of sleep disturbance. [49] Babisch and van Kamp [52] and a later review of studies within the UK [53] concluded that there was an inconsistent association between aircraft noise and children's BP primarily due to methodological differences between studied. In their recent review, Paunovic et al. [54] concluded a tendency towards positive associations, but they also observed large methodological differences between studies. A study among children aged 8-14 years by Babisch et al. [55] concluded that road traffic noise at home as a stressor could affect children's BP.

There is some evidence that short-term cardiovascular reactions during sleep are more pronounced in children. [25,56] Lepore et al [56] concluded that compared with quiet-school children, noisy-school children had significantly lower increases in BP when exposed to either acute noise or non-noise stressors, indicative of a generalized habituation effect. Studies in Serbia [57,58] among schoolchildren and pre-school children indicated a raised BP among children from noisy schools who live in quiet residences compared with children from quiet school and quiet home environments indicating that the effects due to daytime noise exposures while at school were not compensated for by quiet periods while at home .

Discussion

This scoping review has shown that studies into the short and long term effects of noise disturbed sleep in children on health and cognition are scarce. This is expected to change in the near future. In the context of continuing urbanization noise exposure will increase in the coming decades also for young children. Due to the 24 hour economy noise exposure starts earlier and ends later in the day and will continue over the weekend. Since sleep patterns change with age these developments might primarily affect young children and noise policies have to account for these differences in their noise regulations. For example: only in children the deep sleep stage is observed in the later parts of the nights and current curfews around airports do not take this into account. These developments include that not only the moments and places of quiet and restoration are diminishing, but also that sleep disturbance in children might be an increasing problem. In particular the combination with other environmental stressors such as frequent use of computer screens, which has been shown to affect sleep duration as well as sleep quality, will be of concern. New developments in the field of genomics and gene- environment [64] interactions will allow for studying the effects of early childhood exposures later on in life and sleep disturbance is identified as a potentially important mediator in this process. There are new but still highly theoretical notions on early gene-environment interactions [59] which suggest that lifespan exposure to stress influences brain structures involved in cognition and mental health. This sheds new light on the importance of developmental sensitive periods.

In line with the Health Council Netherlands [18] in reviewing the results a distinction was made between acute effects, next day effects, after effects and long term effects. There is insufficient evidence to know whether children are more responsive than adults to other acute biological responses than those found for adults. Studies into the next day or after effects have shown that exposure to increased transport related noise levels were associated with daytime sleepiness and performance on complex tests and problems with sustaining attention. [62] After effects on cognition and performance have been studied in adults only and for adults early night exposure, e.g. aircraft noise before midnight, was shown to be particularly damaging to memory and related cognitive functions [27]. However it is not clear whether these findings apply to children in the same way. It would be interesting to know to what extent the results found for adults are also valid for children, and whether the depth of children's sleep counteract or enhance the slow wave sleep (N3) dominance in the early night.

A more recent study [63] indicated that nighttime noise was found in particular to be associated with more emotional symptoms. This association may be confounded by the presence of sleeping problems and the authors recommend that more longitudinal studies are required to explore the temporal sequence of noise exposure, sleep disturbances and behavioral problems.

Effects on motivation and further studies into the restorative function of sleep have also been brought forward in the literature as important topics for future studies. Regarding the long term health effects of sleep disturbance it has been put forward that an elevated BP during childhood might be a good predictor of hypertension later on in life. The non-dipping effect of diastolic BP at night was found in noise exposed groups, which has previously been identified as independent risk factor for CVD. How this effect is related to early childhood exposure should be studied in more depth.

Several mechanisms were described to explain the association between sleep disturbance and obesity as well as diabetes type 2. Circadian disorganization in relation to sleep deprivation is one of them. An imbalance between leptin and ghrelin can lead to an increased sense of hunger with weight gain as a consequence [46,64]. The risk of diabetes due to sleep disturbance and poorer cognitive performance have been identified as accompanying long term effects of disturbed circadian rhythms. The hypothesis that childhood noise related sleep disturbance could lead to more serious sleep disturbance and insomnia later on in life is mentioned in the literature, but would need much more attention in prospective cohort studies. Potential mechanisms brought forward in relation to the effect of sleep disturbance and cognitive effects were extensively described by Stansfeld at al [26]. Evidence is still lacking, but narrowing of the attention focus, impairments of auditory discrimination and speech perception, and communication difficulties in the classroom and learned helplessness were brought forward as plausible candidates. It is not clear yet if and how noise-related behavior in the long term has a negative influence on children's health and learning.

Future studies into the mechanisms behind the issue of noise and sleep in children should be placed in a broader environmental and cultural context as was canvassed by Knutson [46] in her model presenting the environmental factors that can impair sleep in conjunction with biological and cultural factors.

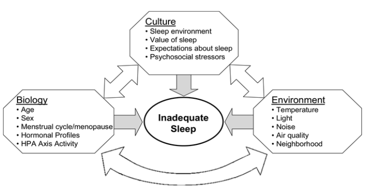

Figure 3: Factors associated with biology, culture and environment that can impact and interact with sleep to increase (source: Knutson [46] with permission)

It is known from previous studies that sleep could be disturbed when the ambient temperature is too hot, too humid or too cold [60]. Another factor of influence is light, either caused by natural light (Northern hemisphere) or artificial sources in the bedroom due to street lamps, greenhouses, indoor lighting or daytime sleep. One mechanism through which exposure to light at night can impair sleep is the inhibition of melatonin. Transport related pollutions which are common characteristics of large urban areas according to the model are noise that can impair sleep via physiological arousal as measured by (motility, EEG awakenings, BP changes and heart rate variability) and air pollution both indoor and outdoor via breathing. Recently it was shown [65] that bruxism during sleep was more prevalent in children exposed to light and noise.

Lastly, the model mentions neighborhood characteristics which primarily refer to social safety. Studies addressing the joint effect of environmental and neighborhood aspects on sleep quality are rare but can be considered as important in particular to understand the disparities in sleep between different populations [46].

Conclusion

Effects of noise disturbed sleep in children is an understudied topic, while due to the 24 economy and ongoing process of urbanization nighttime noise exposure is expected to pose an increasing problem. Evidence on acute and long term effects of childhood sleep disturbance is still scarce. In specific more information is needed on long term health effects and long term impacts on cognitive development of disturbed sleep in early childhood. A more integrated approach is needed to further the field including experimental as well as epidemiological studies such as prospective cohort studies.

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Article

Aircraft Noise and Psychological Ill-Health: The Results of a Cross-Sectional Study in France

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Abstract: *Background:* The effects of aircraft noise on psychological ill-health have not been largely investigated and remain to be discussed. No study has been performed in France on the health effects of aircraft noise. *Objectives:* The present study aimed to investigate the relationship between aircraft noise in dB and in terms of annoyance and psychological ill-health in populations living near airports in France. *Methods:* A total of 1244 individuals older than 18 and living near three French airports (Paris–Charles de Gaulle, Lyon–Saint-Exupéry and Toulouse–Blagnac) were randomly selected to participate in the study. Information about their personal medical history and socioeconomic and lifestyle factors was collected by means of a face-to-face questionnaire performed at their place of residence by an interviewer. Psychological ill-health was evaluated with the 12-item version of the General Heath Questionnaire (GHQ-12). For each participant, outdoor aircraft noise exposure in dB was estimated by linking their home address to noise maps. Objective noise exposure in dB was considered to be the primary exposure of interest. Four noise indicators referring to three different periods of the day were derived and used for the statistical analyses: L_{den}, $L_{\mathrm{Aeq,24hr}}$, $L_{\mathrm{Aeq,6hr–22hr}}$, and L_{night}. Noise annoyance and noise sensitivity were the secondary risk factors of interest. Logistic regression models were used with adjustment for potential confounders. *Results:* The participation rate in the study was 30%. Approximately 22% of the participants were considered to have psychological ill-health according to the GHQ-12. No direct association was found between exposure to aircraft noise in dB and psychological ill-health. However, annoyance due to aircraft noise and noise sensitivity were both significantly associated with psychological ill-health. Moreover, a gradient was evidenced between annoyance and psychological ill-health, with increasing ORs from 1.79 (95% CI 1.06–3.03) for people who were not all annoyed to 4.00 (95% CI 1.67–9.55) for extremely annoyed people. *Conclusions:* These findings confirm the results of previous studies, suggesting there is no direct association between aircraft noise exposure in dB and psychological ill-health, but there is a significant relationship between noise sensitivity or annoyance due to aircraft noise and psychological ill-health. This supports the hypothesis that psychological aspects, such as noise annoyance and noise sensitivity, play important roles in the association between environmental noise and adverse effects on health. However, further studies are necessary in order to better understand the links between these variables.

Keywords: epidemiology; aircraft noise exposure; psychological ill-health

1. Introduction

Transportation noise continues to be a major source of environmental noise pollution and represents a major issue for public health [1]. According to the World Health Organization (WHO), at least one million healthy life years are lost every year due to traffic-related noise in Western Europe [2]. Sleep disturbance and annoyance due to noise are the most serious consequences of environmental noise, mostly related to road traffic [2]. Aircraft noise is the third most important source, after road traffic and railway noise, affecting human exposure above the levels considered to be annoying or to have adverse effects on health [3]. Aircraft noise is perceived as a major environmental stressor near airports. The impact of long-term exposure to aircraft noise on health is of growing concern [4] due to the steady rise in flights as well as the increasing dissatisfaction by nearby inhabitants with this noise [5].

Many studies have demonstrated the adverse effects of exposure to aircraft noise on health, such as annoyance [5,6], sleep disturbance [7,8], cardiovascular diseases including hypertension [9–13], and alteration of cognitive performances among children [14,15]. The association between noise exposure and noise annoyance has been extensively investigated, and aircraft noise has been found to be the most annoying noise source among all transportation noise sources when standardized for noise exposure level [6]. Recently, it has been suggested that annoyance due to aircraft noise has increased in previous years [5,16,17].

In addition, some studies support the hypothesis that psychological aspects such as noise annoyance and noise sensitivity play important roles in the association between environmental noise and adverse effects on health [18–20]. Noise is a psychosocial stressor that activates the sympathetic and endocrine systems [21]. As some studies have shown that endocrine distress can lead to psychological symptoms such as depression or anxiety [22,23], the question has been raised as to whether aircraft noise exposure, in dB or in terms of noise sensitivity or noise annoyance, is related to psychological ill-health [24]; however, this has not been largely investigated, and remains to be discussed.

The General Health Questionnaire (GHQ) has been extensively used in large-scale studies for the evaluation of psychological ill-health in the community setting [25]. The four studies investigating the effects of aircraft noise exposure in dB on mental health showed consistent results—they did not find any significant association between aircraft noise exposure and psychological ill-health based on the GHQ-30 [26], the GHQ-28 [27], or the GHQ-12 [28]. Only Miyakawa et al. in Japan showed a significant correlation between aircraft noise exposure and moderate/severe somatic symptoms identified by the GHQ-28 in people sensitive to noise [27]. However, all of these authors observed significant associations between psychiatric illness and noise annoyance [26,28] or noise sensitivity [26,29]. Furthermore, consistent results have been shown regarding the effects of aircraft noise on psychological symptoms, such as depression and anxiety [30], but not for clinically defined psychiatric disorders. Therefore, the effects of aircraft noise on psychological ill-health remain unclear and are still under discussion. Moreover, these effects have never been studied in France and have been investigated by only very few studies in Europe. The study by Tarnopolsky et al. was published in 1980 [26], but aircraft noise levels have changed since the 1980s.

The objective of the DEBATS research program (Discussion on the health effects of aircraft noise) is to investigate the effects of long-term aircraft noise exposure on health among populations living near airports in France. A previous result from the DEBATS study provided support that psychological stress is induced by aircraft noise exposure, resulting in hypothalamus-pituitary-adrenal axis dysregulation and a flattened cortisol rhythm, and notably, a lower ability to decrease cortisol levels at night [31]. The present paper addresses, more specifically, the issue of psychological ill-health among populations living near airports in France, and its association with aircraft noise exposure, annoyance due to aircraft noise and noise sensitivity. The question of whether exposure to high levels of aircraft noise is associated with a higher risk of psychological ill-health is raised.

2. Methods

2.1. Study Population

The present study included people older than 18 years of age at the time of the interview, living in the study area near one of the following three French international airports: Paris–Charles de Gaulle, Lyon Saint–Exupéry, or Toulouse–Blagnac [11]. The study area was defined based on noise contours produced for France's largest airports, representing four categories of aircraft noise exposure in terms of L_{den}: <50, 50–54, 55–59, and ≥60 dB. The L_{den} is an annual noise indicator which describes the average equivalent sound pressure levels over a complete year for day (6 a.m. to 6 p.m.), evening (6 p.m. to 10 p.m.), and night (10 p.m. to 6 a.m.) where evening and night sound pressure levels receive a 5 dB and a 10 dB penalty, respectively. The L_{den} is the "general purpose" indicator defined in the EU directive 2002/49 relating to the assessment and management of environmental noise.

Households were randomly selected from a phone directory, based on their address in the study area. Once a household was contacted by phone, a respondent was then randomly selected from within the household. The participant signed and returned an informed consent form by mail. Almost 40% of those contacted who refused to participate responded to a short questionnaire about their demographic and socioeconomic characteristics. It was also possible to compare the characteristics of the participants to those of people who refused to participate (non-participants), as well as to those of the study population, using data from the French national census.

In total, 1244 participants (549 men and 695 women) were included in the study and responded to a questionnaire during a face-to-face interview at their place of residence in 2013. This questionnaire collected demographic and socioeconomic information; lifestyle factors including smoking, alcohol consumption, and physical activity; personal medical history in terms of sleep disturbances, cardiovascular diseases, anxiety, depressive disorders, medication use; and annoyance due to noise exposure. Blood pressure and anthropometric measurements (weight, height, and waist circumference) were also recorded, and saliva samples were taken to determine cortisol levels. The analyses presented in the present paper were carried out on the 1222 participants (688 women and 534 men) who had complete information for all the covariates included in the models.

2.2. Exposure Assessment

Noise contours are routinely produced by Paris Airports, and the French Civil Aviation Authority for Toulouse–Blagnac and Lyon Saint–Exupéry airports, with the "Integrated Noise Model" (INM) using a height of 4 m for noise simulations [32]. The INM is an internationally well-established computer model that evaluates aircraft noise impacts near airports and outputs noise contours for an area. Outdoor aircraft noise exposure was assessed in 1 dB intervals for each participant with a linkage between the noise contours and their home address using a geographic information system (GIS) technique. Four noise indicators referring to three different periods of the day were derived and used for the statistical analyses: L_{den}, $L_{\text{Aeq,24hr}}$, $L_{\text{Aeq,6hr–22hr}}$, and L_{night}. The L_{den} was used to select the participants (Table 1). The $L_{\text{Aeq,24hr}}$, $L_{\text{Aeq,6hr–22hr}}$, and L_{night} correspond to the average of sound levels during the corresponding periods of time.

Table 1. Comparison of the demographic and socioeconomic characteristics of participants, non-participants, and the study population.

	Participants		Non-Participants [1]		Study Population [2]
	n	%	*n*	%	%
Noise level (L_{den} in dB)					
Paris-Charles de Gaulle					
<50	108	17%	324	22%	-
50–54	102	16%	215	14%	-
55–59	208	34%	464	31%	-
≥60	202	33%	497	33%	-

Table 1. *Cont.*

	Participants		Non-Participants [1]		Study Population [2]
	n	%	*n*	%	%
Toulouse-Blagnac					
<50	104	25%	198	29%	-
50–54	103	25%	159	23%	-
55–59	101	25%	160	23%	-
≥60	103	25%	169	25%	-
Lyon Saint-Exupery					
<50	105	49%	166	57%	-
50–54	102	48%	124	43%	-
55–59	5	2%	1	0%	-
≥60	1	1%	0	0%	-
Gender					
Men	549	44%	1028	41%	48%
Women	695	56%	1449	59%	52%
Age					
18–34	226	18%	497	20%	26%
35–44	236	19%	435	18%	17%
45–54	266	21%	416	17%	19%
55–64	260	21%	448	18%	15%
65–74	185	15%	332	13%	13%
≥75	71	6%	331	13%	10%
Marital status					
Single	253	20%	555	22%	-
Married	782	63%	1326	54%	-
Widowed	76	6%	281	11%	-
Divorced	133	11%	194	8%	-
Other	0	0%	10	0%	-
Unknown/refusal	0	0%	111	5%	-
Socio-occupational category					
Farming, trade	32	2%	81	3%	5%
Executive, superior Intellectual occupation	227	18%	322	13%	9%
Intermediate	220	18%	103	4%	14%
Office worker	268	22%	749	30%	17%
Manual worker	79	6%	145	6%	13%
Retiree	337	27%	929	38%	25%
Never worked or long-term unemployed (students, housewives, other)	81	7%	134	5%	17%
Unknown/refusal	0	0%	14	1%	-

[1] People randomly selected and contacted by phone, but who refused to participate. These people responded to a short questionnaire about their demographic and socioeconomic characteristics. [2] The distribution of the study population is based on data from the 1999 INSEE census, adjusted in 2007, for individuals aged 18 and over and living in one of the 161 municipalities of the study area.

2.3. Psychological Illness

The presence of psychological illness was determined with the 12-item version of the GHQ [33]. The GHQ-12 is a self-reporting instrument for the detection of mental disorders within a community, such as temporary alterations of normal psychological functioning, stable disorders, and stress-related alterations of adaptive behavior. Each of the 12 questions has a four-point response scale, usually scored in a bimodal fashion (respectively 0, 0, 1, 1): ‘not at all’, ‘no more than usual’, ‘rather more than usual’, and ‘much more than usual’. A total score between 0 and 12 was then calculated by summing up the scores of the individual items—the higher the GHQ-12 score, the more psychological distress reported. This total score was then dichotomized in order to determine the presence of psychological ill-health. According to prior studies [34–36] and to Goldberg’s recommendations [33,37,38], participants with a total score ≥3 were considered to have psychological ill-health.

2.4. Confounding Factors

The following potential confounders were obtained from the questionnaire with valid and reliable questions used in previous other studies [28,39,40], and introduced into multivariate regression models: gender (dichotomous), age (six categories: 18–34; 35–44; 45–54; 55–64; 65–75; >75 years old), country of birth (two categories: France-born/foreign-born), occupational activity (dichotomous: no/yes), education (three categories: <French high school certificate/French high school certificate/>French high school certificate), marital status (four categories: single/married/widowed/divorced), smoking habits (four categories: non/ex/occasional/daily smoker), alcohol consumption (four categories: no/light/moderate/heavy drinker), number of work-related stress and major stressful life events (three categories: 0/1/more than 2), household monthly income (three categories: <2300; 2300–4000; ≥4000 euros), sleep duration (five categories: ≤5 h; 6 h; 7 h; 8 h; ≥9 h), antidepressant use (two categories: no/yes), and self-reported anxiety (two categories: extremely/a lot versus moderately/slightly/not at all).

Other a priori confounders, such as house characteristics (window opening, insulation of roof and/or windows) or personal medical history (cardiovascular or other physical diseases) were also initially considered. However, as they were not associated with psychological ill-health in the univariate analysis ($p > 0.20$), they were not included in the multivariate analysis.

Noise sensitivity and annoyance due to aircraft noise were the secondary risk factors of interest. Noise sensitivity was assessed using the following question: "Regarding noise in general, compared to people around you, do you think that you are: less sensitive than, or as sensitive as, or more sensitive than people around you?" Aircraft noise annoyance was assessed by a standardized question with a verbal five-point answer scale as recommended by the International Commission on the Biological Effects of Noise (Icben): "Thinking about the last 12 months when you are at home, how much does aircraft noise bother, disturb or annoy you?" There were five possible answers: extremely, very, moderately, slightly or not at all.

2.5. Statistical Analysis

Associations between psychological ill-health and aircraft noise in terms of dB, noise sensitivity or noise annoyance were assessed with logistic regression models. The M0 model included only aircraft noise exposure in dB as an explanatory variable. The M1 model included aircraft noise exposure in dB as the primary exposure of interest, together with major potential confounders as covariates. The M2 model included aircraft noise exposure in dB as the primary exposure of interest, as well as noise sensitivity and noise annoyance as the secondary risk factors of interest, together with confounders. Interactions between noise sensitivity and aircraft noise exposure, annoyance and aircraft noise exposure, and annoyance and noise sensitivity were analyzed in the M2 model.

The linearity of the relationship between the dependent variable and aircraft noise exposure was tested using generalized additive models, including a smooth cubic function with linear and quadratic terms for aircraft noise exposure [41]. As the quadratic term was not significant in these models, associations with the continuous exposure variable were finally estimated per 10 dB increase and are presented in this paper.

All the statistical analyses were performed with SAS 9.3 (SAS Software [program] 9.3 version. USA: Cary, NC, USA, 2011).

2.6. Ethics Approval

Two national authorities in France, the French Advisory Committee for Data Processing in Health Research and the French National Commission for Data Protection and the Liberties approved the present study.

3. Results

Overall, the participation rate was 30% (1244 participants/4202 eligible people). Participation rates differed among populations situated near the three airports: 25% for Paris–Charles de Gaulle airport, 34% for Toulouse–Blagnac airport, and 39% for Lyon–Saint-Exupéry airport. In contrast, similar numbers of participants from the four 5 dB-categories of aircraft noise exposure were included. The demographic and socioeconomic characteristics were quite similar among participants, people who refused to participate but responded to the short questionnaire (non-participants), and the study population (Table 1); the participants were a little older and were more likely to have executive or superior intellectual occupations.

The prevalence of psychological ill-health based on the GHQ-12 was 22% (17% in men and 25% in women). Table 2 shows the odds ratios (ORs) and their 95% CIs for psychological ill-health in relation to levels of aircraft noise in dB and the confounders used in the univariate analysis. The percentage of participants with psychological ill-health did not differ across the four categories of aircraft noise exposure. Women (compared to men), 45 to 54-year-old participants (compared to 18–34-year-old participants), foreign-born participants (compared to France-born participants), daily smokers (compared to non-smokers), people who reported two stressful life events or more (compared to people with no event), people with a household monthly income lower than 2300 euros (compared to people with a household monthly income higher than 4000 euros), and participants who reported anxiety had a higher risk of psychological ill-health according to the GHQ-12. Noise sensitivity and annoyance due to aircraft noise were also significantly associated with psychological ill-health—people who described themselves as more sensitive to noise than others and people who were moderately, very, or extremely annoyed by aircraft noise had a higher risk of psychological distress, as evaluated with the GHQ-12.

Table 2. Odds ratios (ORs) for psychological ill-health in relation to major confounders in univariate logistic models.

	N	Number of Participants with GHQ-12 $\geq$ 3	Number of Participants with GHQ-12 < 3	OR	(95% CI)
Noise levels (L_{den} in dB)					
<45	82	25 (30%)	57 (70%)	1	-
45–49	235	49 (21%)	186 (79%)	0.60	(0.34–1.06)
50–54	307	62 (20%)	245 (80%)	0.58	(0.33–1.00)
55–59	314	66 (21%)	248 (79%)	0.61	(0.35–1.04)
$\geq$60	306	66 (22%)	240 (78%)	0.63	(0.36–1.08)
Noise sensitivity					
As sensitive or less sensitive than people around you	866	154 (18%)	712 (82%)	1	-
More sensitive than people around you	369	111 (30%)	258 (70%)	**1.99**	**(1.50–2.64)**
Annoyance due to aircraft noise					
Not at all annoyed	246	37 (15%)	209 (85%)	1	-
Slightly	312	65 (21%)	247 (79%)	1.49	(0.95–2.32)
Moderately	460	99 (22%)	361 (78%)	**1.55**	**(1.02–2.34)**
Very	186	50 (27%)	136 (73%)	**2.08**	**(1.29–3.35)**
Extremely	40	17 (43%)	23 (57%)	**4.18**	**(2.04–8.56)**
Gender					
Men	549	92 (17%)	457 (83%)	1	-
Women	695	176 (25%)	519 (75%)	**1.68**	**(1.27–2.23)**
Age					
18–34	226	43 (19%)	183 (81%)	1	-
35–44	236	58 (25%)	178 (75%)	1.39	(0.89–2.16)
45–54	266	71 (27%)	195 (73%)	**1.55**	**(1.01–2.38)**
55–64	260	56 (22%)	204 (78%)	1.17	(0.75–1.82)
65–74	185	26 (14%)	159 (86%)	0.70	(0.41–1.18)
$\geq$75	71	14 (20%)	57 (80%)	1.05	(0.53–2.05)

Table 2. *Cont.*

	N	Number of Participants with GHQ-12 ≥ 3	Number of Participants with GHQ-12 < 3	OR	(95% CI)
Country of birth					
France-born	1054	215 (20%)	839 (80%)	1	-
Foreign-born	190	53 (28%)	137 (72%)	**1.51**	**(1.06–2.14)**
Occupational activity					
No	499	100 (20%)	399 (80%)	1	-
Yes	745	168 (23%)	577 (77%)	1.16	(0.88–1.53)
Education					
<French high-school certificate	452	97 (21%)	355 (79%)	1	-
French high-school certificate	215	52 (24%)	163 (76%)	1.17	(0.79–1.72)
>French high-school certificate	577	119 (21%)	458 (79%)	0.95	(0.70–1.29)
Marital status					
Single	253	56 (22%)	197 (78%)	1	-
Married	782	162 (21%)	620 (79%)	0.92	(0.65–1.3)
Divorced	133	34 (26%)	99 (74%)	1.21	(0.74–1.97)
Widowed	76	16 (21%)	60 (79%)	0.94	(0.50–1.75)
Smoking habits					
Non-smoker	625	120 (19%)	505 (81%)	1	-
Ex-smoker	330	74 (22%)	256 (78%)	1.22	(0.88–1.69)
Occasional smoker	19	1 (5%)	18 (95%)	0.23	(0.03–1.77)
Daily smoker	269	72 (27%)	197 (73%)	**1.54**	**(1.10–2.15)**
Alcohol consumption					
No	348	89 (26%)	259 (74%)	1	-
Light	637	134 (21%)	503 (79%)	0.78	(0.57–1.05)
Moderate	193	31 (16%)	162 (84%)	**0.56**	**(0.35–0.88)**
Heavy	54	10 (19%)	44 (81%)	0.66	(0.32–1.37)
Number of work-related stress and major stressful life events					
0	287	46 (16%)	241 (84%)	1	-
1	330	57 (17%)	273 (83%)	1.09	(0.71–1.67)
≥2	627	165 (26%)	462 (74%)	**1.87**	**(1.30–2.69)**
Household monthly income					
≥4000 euros (4500 US$)	319	56 (18%)	263 (82%)	1	-
2300–4000 euros (2600–4500 US$)	474	93 (20%)	381 (80%)	1.15	(0.79–1.65)
<2300 euros (2600 US$)	451	119 (26%)	332 (74%)	**1.68**	**(1.18–2.40)**
Sleep duration					
≤5 h	52	9 (17%)	43 (83%)	0.65	(0.31–1.40)
6 h	256	30 (19%)	126 (81%)	0.74	(0.47–1.18)
7 h	363	88 (24%)	275 (76%)	1	-
8 h	424	94 (22%)	330 (78%)	0.89	(0.64–1.24)
≥9 h	249	47 (19%)	202 (81%)	0.73	(0.49–1.08)
Antidepressant use					
No	1203	255 (21%)	948 (79%)	1	-
Yes	41	13 (32%)	28 (68%)	1.73	(0.88–3.38)
Self-reported anxiety					
Moderately/slightly/not at all	978	122 (12%)	856 (88%)	1	-
Extremely/a lot	266	146 (55%)	120 (45%)	**8.54**	**(6.28–11.61)**

The ORs and their 95% CIs evaluated with the GHQ-12 for psychological ill-health in relation to aircraft noise exposure in three different models (M0, M1 and M2) are presented in Table 3. These analyses involved 1222 participants (688 women and 534 men). They were performed separately for the four noise indicators (L_{den}, $L_{Aeq,24hr}$, $L_{Aeq,6hr\text{-}22hr}$ and L_{night}), but as the results were similar between all noise indicators, they are shown for L_{den} only. No relationship was observed between aircraft noise exposure in dB and psychological distress, regardless of the noise indicator and the inclusion of confounding factors in the models (M0 and M1 models). When noise sensitivity and annoyance due to aircraft noise were both included in the model (M2 model), there was still no association between psychological ill-health and aircraft noise exposure in dB, regardless of the noise indicator. In contrast, relationships were shown between annoyance due to aircraft noise and psychological ill-health, and between noise sensitivity, and psychological ill-health. Moreover, a gradient was observed between annoyance due to aircraft noise and psychological ill-health; ORs ranged from 1.79 (95% CI 1.06–3.03) for people who were not all annoyed to 4.00 (95% CI 1.67–9.55) for extremely annoyed people.

Table 3. Odds ratios (ORs) for the relationship between aircraft noise exposure and psychological ill-health.

	OR	(95%CI)
M0 Model		
L_{den} [1]	0.91	(0.72–1.14)
M1 Model		
L_{den} [1]	1.02	(0.78–1.34)
M2 Model		
L_{den} [1]	0.93	(0.69–1.24)
Noise sensitivity		
Less or as sensitive as people around you	1.00	
More sensitive th. people around you	**1.52**	**(1.09–2.14)**
Annoyance due to aircraft noise		
Not at all annoyed	1.00	
Slightly	**1.79**	**(1.06–3.03)**
Moderately	1.63	(0.98–2.71)
Very	**2.00**	**(1.10–3.64)**
Extremely	**4.00**	**(1.67–9.55)**

[1] Per 10 dB increase. M0 = Univariate regression model including only aircraft noise exposure in terms of L_{den}. M1 = Multivariate regression model including aircraft noise exposure in terms of L_{den} together with the major potential confounders listed in Table 2 (without noise sensitivity and annoyance due to aircraft noise). M2 = Multivariate regression model including aircraft noise exposure in terms of L_{den} together with noise sensitivity, annoyance due to aircraft noise and the major potential confounders listed in Table 2. Bold values are statistically significant ($p < 0.05$).

Finally, no significant interactions were observed between the noise indicators, noise sensitivity or annoyance due to aircraft noise.

4. Discussion

The DEBATS study is the first in France and one of only very few in Europe to investigate the relationship between long-term aircraft noise exposure and psychological ill-health in populations living near airports. The participation rate (30%) was similar to aircraft noise studies completed in Germany, Italy, and in the UK [12]. The prevalence of psychological ill-health evaluated by the GHQ-12 was 22% (17% among men and 25% among women). In contrast, in a Spanish study by Rocha et al., the prevalence of common mental disorders assessed with the GHQ-12 was 30% in women and 17% in men [34]. Further, in a study around Schiphol airport in Amsterdam, carried out in 2005 by van Kamp et al., the prevalence of self-reported mental health complaints evaluated with the GHQ-12 was 26% [28].

The results of the present study confirm those found in the literature, namely that there was no significant association between aircraft noise exposure in dB and psychological ill-health identified with the GHQ-12. However, our findings suggested a gradient between annoyance due to aircraft noise and psychological ill-health, with increasing ORs from 1.79 (95% CI 1.06–3.03) for people who were not all annoyed to 4.00 (95% CI 1.67–9.55) for extremely annoyed people. Miedema and

Oudshoorn [6] showed evidence for a dose–response relationship between aircraft noise exposure and the percentage of highly annoyed people. These exposure–response relationships are used as the standard curves for the assessment and management of environmental noise in the European Union [42]. Therefore, it could be assumed that an increase in aircraft noise exposure leads to an increase in annoyance due to aircraft noise, thus leading to an increase in psychological ill-health. However, further research is necessary to validate this hypothesis.

One of the first studies to assess the effects of aircraft noise on mental health was performed by Tarnopolsky et al. in 1980 [26]. Although the authors did not observe any excess psychiatric morbidity identified by the GHQ-30 in populations exposed to aircraft noise, they showed an association between psychiatric illness and noise annoyance or sensitivity to noise. In the longitudinal study around Schiphol airport in Amsterdam [28], which is the most similar to the DEBATS in terms of methodology, the authors did not observe any association between noise exposure levels or changes in exposure levels after the opening of the fifth runway and mental health complaints as measured by the GHQ-12 (OR = 0.94 for a 3 dB-increase in noise levels in terms of L_{den}, 95% CI = 0.84–1.05). However, people who were severely annoyed by aircraft noise reported more mental health complaints, as assessed by the GHQ-12 (OR = 1.84, 95% CI = 1.38–2.45). In Japan, Miyakawa et al. [27] did not observe any relationship between aircraft noise exposure and psychiatric disorders evaluated with the GHQ-28 but showed a significant correlation between aircraft noise exposure and moderate/severe somatic symptoms in people sensitive to noise. In Spain, outside noise reported as a perceived environmental problem was significantly associated with the prevalence of common mental disorders using the GHQ-12 [34]. Finally, in the United Kingdom, high noise sensitivity was identified by Stansfeld et al. [29] as a predictor of psychological distress using the GHQ-30.

In the present study, a relationship was observed between noise sensitivity and psychological ill-health, and between annoyance due to aircraft noise and psychological ill-health, irrespective of noise exposure. Both relationships were significant, underlining the independent effects of both factors and supporting the hypothesis that psychological aspects such as noise annoyance and noise sensitivity seem to play important roles in the association between environmental noise and adverse effects on health.

On one hand, it has been postulated that, if a (direct) relationship does not exist between noise exposure in dB and psychological ill-health, annoyance may be regarded as an intermediate step in the causal chain between aircraft noise exposure and health, in particular, psychological ill-health. However, the relationship between noise annoyance and psychological ill-health is still under discussion. Because of the cross-sectional design of major studies, the direction of the association has been questioned. Extremely annoyed people might be more at risk of having psychological ill-health, but it is also possible that people with psychological ill-health might be more at risk of being annoyed and then be more willing to attribute their symptoms to noise [19,20,43]. However, it was not possible to answer this question in the present study.

On the other hand, noise sensitivity is considered as a moderating factor of the effects of aircraft noise exposure on noise annoyance [18,44]. It has been suggested that noise sensitivity could also influence the effects of noise on physical and psychological ill-health [45]. Noise sensitivity has been suggested to be a potential indicator of vulnerability to environmental stressors, not only to environmental noise [46,47], it has also been postulated to be a proxy measure of anxiety [29]. However, further research is necessary to better understand how noise sensitivity and psychological ill-health are linked.

A specific strength of the present study relates to the evaluation of noise exposure. Outdoor aircraft noise exposure was estimated for each participant with modeled noise levels produced by the French Civil Aviation Authority using INM software. Most of the differences between these modeled noise levels and measurements from permanent stations [48] or from specific campaigns [49] were between 0.5 and 1.5 dB in terms of L_{den}, showing the close correspondence between modeled and measured noise levels.

In terms of limitations, aircraft noise exposure was estimated in front of each participant's residence. Nevertheless, this estimation did not take into account the building outdoor insulation and the opening/closing practice of the windows, thus leading to a potential misclassification of the participants according to their noise levels. Moreover, many of the participants, at least those who were at work, were more likely to be away from their homes during the day. No information was available about the daytime aircraft noise exposure of the participants when they were away from their homes, for example, at their workplace. Thus, misclassification of exposure could have occurred, especially regarding daytime exposure. However, it is unlikely that the exposure classification would depend on the psychological distress of the participants. Therefore, such non-differential misclassification would have induced an appreciable downward bias if there is a true association between aircraft noise exposure and psychological ill-health, thus explaining the absence of an association observed in the present study.

Furthermore, a selection bias cannot be excluded in the present study. Participants were slightly different from people who refused to participate but responded to the short questionnaire, particularly in regards to their age and their socio-occupational category. In addition, these non-participants were not representative of all people who refused to participate. The representativeness of a sample randomly selected from a phone directory (certainly with a better socioeconomic situation than that of the study population) could be raised but could not be quantified in the present study. The same applies for the representativeness of the study population as compared with all people living near an airport in France. However, due to insufficient information, it was not possible to characterize this latter population.

Another form of selection bias may have occurred during the estimation of the prevalence of psychological ill-health. This prevalence may have been underestimated in the higher noise zones if unsusceptible individuals were selected in these zones. The possible adverse effects of aircraft noise on psychological ill-health could have led to a lower proportion of sensitive people among those living near airports, particularly in the higher noise zones. People prone to illness, especially to psychological ill-health, may be reluctant to live in noisy conditions. Little information is available in the DEBATS study to judge whether people with psychological problems have chosen not to live close to airports. However, if this had occurred, it would have resulted in an underestimation of the association between aircraft noise exposure and psychological ill-health in this study. It is therefore possible that a background of better mental health in the higher noise zones could hide noise effects on psychological ill-health in this study.

It is unlikely that a lack of statistical power caused the failure of the present analysis to find a significant association between aircraft noise exposure in dB and psychological ill-health. Indeed, the number of participants included in the DEBATS study (n = 1244) was very significant. Other studies did not observe any association in this regard, despite a higher number of participants and thus greater statistical power: 2671 people were included in the study by van Kamp et al. [28], and 2861 in the one by Miyakawa et al. [27]. Moreover, a significant association was previously shown between aircraft noise exposure and a smaller variation in cortisol levels among the participants in the DEBATS study [31]. This finding provides some support for a link between psychological stress and aircraft noise exposure, and, as endocrine distress could lead to psychological symptoms such as depression or anxiety [22,23], it suggests a method by which aircraft noise exposure could cause psychological ill-health. Nevertheless, such an association was not observed in the present analysis.

A more appropriate indicator of psychological distress than the GHQ might show a relationship with aircraft noise exposure in dB. The fact that psychological ill-health was estimated using a questionnaire could be a limitation in the present study although it has been used by most previous studies on psychological illness [26–29,34,50]. The GHQ-12 is a reliable screening questionnaire that is particularly recommended for identifying minor psychological disorders within community settings. Since the GHQ-12 is brief, simple, easy to complete, and its application in research settings as a screening tool is well documented, the GHQ-12 has been widely used in large-scale studies in the way that it can serve as a general indicator of distress. Nevertheless, it is not a tool for indicating a clinical diagnosis. Moreover, the double dichotomization (of the response scale by using the bimodal scoring method and of the total score by considering participants with a total score $\geq$3 as having psychological ill-health) raised the question of the sensitivity of the scale measuring psychological disorders. However, the results remained similar when the four-point response scale of the 12 questions was scored using the Likert scoring method (0, 1, 2, 3, respectively) or when linear regression models with the total score as a continuous outcome variable were used. Prescribed and non-prescribed medication could also be used as proxies to characterize mental health. For example, the largest study to date, which included around six major European airports—the HYpertension and Exposure to Noise near Airports (HYENA) study—found that a 10 dB increase in day-time ($L_{\mathrm{Aeq,\ 6hr–22hr}}$) or night-time ($L_{\mathrm{night}}$) aircraft noise was associated with a 28% increase in anxiety medication use, but not with anti-depressant medication use [51]. Information about prescribed and non-prescribed medication taken by the participants was also collected in the present study. The results presented here considered anti-depressant medication to be a confounding factor but they remained unchanged when this variable was not introduced in the models. Further research is necessary to better understand the relationships between aircraft noise exposure and medication use (including anti-depressant use).

Only a standardized clinical interview including questions about the number and the severity of symptoms can measure psychiatric disorders, but this can be expensive and time consuming for large-scale epidemiological studies and the response rate may be low. In the last few years, some epidemiological studies have tried to investigate mental health based on clinical diagnosis and average noise exposure—both from road traffic and airport noise. In Germany, Orban et al. suggest that exposure to residential road traffic noise increases the risk of depressive symptoms [52]. A large case-control study in the region of Frankfurt international airport by Seidler et al. indicates that traffic noise exposure—from aircraft, road traffic, and railway—might lead to depression [53]. However, further prospective research is needed to confirm the results of these studies and to deepen knowledge of the causal pathway between noise exposure and depression.

5. Conclusions

The DEBATS study is the first in France and one of only very few in Europe to investigate the relationship between long-term aircraft noise exposure and psychological ill-health in populations living near airports. The results of this study are consistent with those found in the literature, suggesting no association between aircraft noise exposure in dB and psychological ill-health evaluated with the GHQ, but showing an association between noise sensitivity or annoyance due to aircraft noise and psychological ill-health. In addition, a gradient was shown between annoyance due to aircraft noise and psychological ill-health. These findings support the hypothesis that psychological aspects such as noise annoyance and noise sensitivity play important roles in the association between environmental noise and adverse effects on health. Nevertheless, further research is needed to disentangle the possible effects of noise, sensitivity to noise, and annoyance due to noise on psychological ill-health, as well as how these factors are linked.

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RESEARCH

Aircraft noise and cardiovascular disease near Heathrow airport in London: small area study

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Abstract

Objective To investigate the association of aircraft noise with risk of stroke, coronary heart disease, and cardiovascular disease in the general population.

Design Small area study.

Setting 12 London boroughs and nine districts west of London exposed to aircraft noise related to Heathrow airport in London.

Population About 3.6 million residents living near Heathrow airport. Risks for hospital admissions were assessed in 12 110 census output areas (average population about 300 inhabitants) and risks for mortality in 2378 super output areas (about 1500 inhabitants).

Main outcome measures Risk of hospital admissions for, and mortality from, stroke, coronary heart disease, and cardiovascular disease, 2001-05.

Results Hospital admissions showed statistically significant linear trends (P<0.001 to P<0.05) of increasing risk with higher levels of both daytime (average A weighted equivalent noise 7 am to 11 pm, $L_{Aeq,16h}$) and night time (11 pm to 7 am, L_{night}) aircraft noise. When areas experiencing the highest levels of daytime aircraft noise were compared with those experiencing the lowest levels (>63 dB *v* ≤51 dB), the relative risk of hospital admissions for stroke was 1.24 (95% confidence interval 1.08 to 1.43), for coronary heart disease was 1.21 (1.12 to 1.31), and for cardiovascular disease was 1.14 (1.08 to 1.20) adjusted for age, sex, ethnicity, deprivation, and a smoking proxy (lung cancer mortality) using a Poisson regression model including a random effect term to account for residual heterogeneity. Corresponding relative risks for mortality were of similar magnitude, although with wider confidence limits. Admissions for coronary heart disease and cardiovascular disease were particularly affected by adjustment for South Asian ethnicity, which needs to be considered in interpretation. All results were robust to adjustment for particulate matter (PM_{10}) air pollution, and road traffic noise, possible for London boroughs (population about 2.6 million). We could not distinguish between the effects of daytime or night time noise as these measures were highly correlated.

Conclusion High levels of aircraft noise were associated with increased risks of stroke, coronary heart disease, and cardiovascular disease for both hospital admissions and mortality in areas near Heathrow airport in London. As well as the possibility of causal associations, alternative explanations such as residual confounding and potential for ecological bias should be considered.

Introduction

Although the literature on population annoyance associated with aircraft noise is extensive,[1 2] little research has been conducted on the potential effects of aircraft noise on cardiovascular health.[2] Most studies of the health effects associated with aircraft noise have focused on blood pressure and the risk of hypertension.[3-8] The few reports of aircraft noise and risk of stroke, coronary heart disease, or cardiovascular disease are inconsistent,[9-12] partly reflecting reduced statistical power

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Supplementary information

because of the small proportion of the population exposed to high aircraft noise levels.[10 11]

Noise levels show a graded, direct relation with prevalence of annoyance. This is greater for aircraft noise than for other environmental noise sources—that is, road traffic or rail[1]; community annoyance due specifically to aircraft noise seems to have increased in the past 30 years.[13] Noise is associated with activation of the sympathetic nervous system.[14] In animal models, chronic exposure to noise leads to increases in blood pressure,[15 16] and in humans noradrenaline (norepinephrine) levels,[17] whereas acute exposure to non-habitual loud noise increases adrenaline (epinephrine) levels.[17] Experimental studies of humans acutely exposed to noise at very high level also show increases in blood pressure[18] and heart rate.[19]

Heathrow airport, situated in a densely populated area in west London, is one of the busiest airports in the world. Reports have shown an association between aircraft noise, especially at night, and hypertension,[3] acute increases in blood pressure,[7] and self reported cardiovascular disease[12] in the population living near airports, including Heathrow. We investigated the risks of stroke, coronary heart disease, and cardiovascular disease hospital admissions and mortality in areas exposed to aircraft noise near Heathrow airport.

Methods

We carried out analyses comparing rates of hospital admissions for cardiovascular disease and mortality in neighbourhoods (small areas) exposed to different levels of aircraft noise related to Heathrow airport. We used a standard noise metric, the A weighted equivalent (Aeq) sound pressure level (L), denoted as L_{Aeq}. The human ear is more sensitive to some frequencies than others. The L_{Aeq} devalues lower frequencies compared with medium and higher frequencies,[20] and uses a set of mathematical curves to adjust the sound pressure level to the relative loudness perceived by human hearing. We defined daytime noise ($L_{Aeq,16h}$) as the average A weighted equivalent noise from 7 am to 11 pm and night time noise (L_{night}) from 11 pm to 7 am.

Study area and population

The study area comprised 12 London boroughs and nine districts west of London exposed to aircraft noise related to Heathrow airport, defined as being partly or wholly within the 2001 50 dB noise contour for Heathrow aircraft during the daytime ($L_{Aeq,16h}$) supplied by the Civil Aviation Authority (fig 1⇓). Additionally, we had confounder data for particulate air pollution and road traffic noise for the 12 London boroughs (data for districts outside London were not readily comparable with the data available for London).

We defined neighbourhoods (small areas) by using the national census geographical units, which are census output areas and super output areas. The study area comprised 12 110 census output areas (average 297 inhabitants, area 0.13 km^2) and 2378 super output areas (1510 inhabitants, area 0.65 km^2). We used the census output area as the unit of analysis for hospital admissions and the super output area, an aggregate of on average five census output areas, for mortality as the numbers of deaths were insufficient for meaningful analyses at census output area level. We used Office for National Statistics annual mid-year population estimates by age and sex for 2001-05 at London borough or district level, which we then disaggregated to census output areas and super output areas using the UK 2001 census age-sex distribution.

Aircraft noise data

From the Civil Aviation Authority we obtained aircraft noise data related to Heathrow airport for 2001 on 10 m × 10 m grids. The noise data had been modelled using the UK Civil Aircraft Noise Contour Model ANCON, which uses information on flight paths of arriving and departing aircraft along with factors such as height, speed, and engine power to derive noise at ground level.[21]

We calculated population weighted annual average noise levels for daytime and night time aircraft noise for census output areas and super output areas. This was done because the noise grid was smaller than the area of the census output area or super output areas and populations are not evenly distributed (for example, a census output area has on average 125 addresses and six postcodes that may cluster to one or other side of the census output area) so a simple area averaging would not accurately represent population exposures (see supplementary appendix).

Health data

We extracted post coded data on hospital admissions (main reason for admission, first episode of stay in a given year) and deaths (by underlying cause) for the study area, 2001-05, from Office for National Statistics and Department of Health data held by the UK Small Area Health Statistics Unit at Imperial College London. Data were obtained for stroke (ICD-10 codes I61, I63-I64, international classification of diseases, 10th revision), coronary heart disease (ICD-10 I20-I25), and cardiovascular disease (ICD-10 Chapter I) and then linked these by postcode (average 23 households) to census output area and super output area.

Data on potential confounders

We included ethnicity, deprivation, and a smoking proxy at census output area and super output area level as potential confounders. Area level ethnic composition and deprivation from the 2001 census were obtained from the Office for National Statistics. For the two major ethnic groups in London, we categorised areas by South Asian ethnicity (census term "Asian or Asian British," for which we included only "Indian," "Pakistani," and "Bangladeshi") and black ethnicity (census term "Black or Black British," which includes "Black Caribbean," "Black African," and "Other Black"). We used the following cut points: the national average (%) for England and Wales at census output area level (4% for South Asian, 2% for black ethnicity), double the national average (8%, 4%), and 50% South Asian or black ethnicity—areas where these comprised the majority ethnic group. This gave us four categories for each ethnicity, where the reference categories were less than or equal to the national average (%) for that ethnic group (≤4% for South Asian and ≤2% for black ethnicity). The deprivation score used was Carstairs index,[22] categorised in fifths. As a proxy measure for area level smoking we used smoothed lung cancer mortality (ICD-10 codes C33-C34) relative risk estimates, 2005, for census output areas and super output areas,[23] since data on individual smoking or smoking prevalence were not available.

For the 12 London boroughs within the study area we also obtained data on air pollution and daytime road noise. For air pollution, the Environmental Research Group at King's College London provided estimates of annual mean particulate matter of 10 microns or less (PM_{10}) at spatial resolution of 20 m × 20 m for 2001, using dispersion modeling as detailed in the London Emissions Toolkit and London Air Pollution Toolkit.[24] We obtained data on daily average road traffic noise for 2001 from the Department for Environment, Food and Rural Affairs (Defra), expressed in continuous A weighted equivalent sound pressure levels ($L_{Aeq,16h,road}$) on 10 m × 10 m grids at 1 dB resolution between ≥50 dB and ≤75 dB. Road traffic noise data (major roads) had been generated to comply with the European Noise Directive 2002/49/EC (http://ec.europa.eu/environment/noise/directive.htm) and modeled using the calculation of road traffic noise method at a height of 4 m above ground using characteristics of the road network.[25] We linked the air pollution and road noise data to census output area and super output area using population weighting (see supplementary appendix).

Statistical analyses

Correlations between aircraft noise and potential confounders were assessed using Goodman Kruskal tau rank correlation coefficients.

For the entire study area we carried out a small area analysis of aircraft noise and the three cardiovascular outcomes, adjusted for potential confounders at area level (census output area or super output area): age, sex, South Asian and black ethnicity, deprivation, and smoking proxy (lung cancer mortality risk). We conducted a sensitivity analysis for the 12 London boroughs (London area) additionally including particulate air pollution (PM_{10}) and road noise as potential confounders.

We grouped daytime aircraft noise and road noise into six categories from ≤51 to >63 dB in increments of 3 dB, which represents a doubling in sound intensity that is just perceptible as a change in loudness to the human ear. For aircraft noise, 57 dB L_{Aeq} is taken as the point at which noticeable community annoyance starts to occur[26 27]; the Civil Aviation Authority attempts to minimise areas exposed to this level of noise or higher, measured as the daytime $L_{Aeq,16h}$ over a 92 daytime summer period.[27] Our $L_{Aeq,16h}$ aircraft noise categories include a 57 dB cut point, although we use an annual not summertime average (fig 1). Night time aircraft noise affected fewer areas (fig 1), and 5 dB categories (≤50, >50-55, and >55 dB) were used.

To aid comparisons between daytime and night time aircraft noise, we also ran daytime analyses using the same 5 dB categories. The correlation between daytime and night time aircraft noise categories was almost perfect (τ ≥0.98, see supplementary table 2) so we did not include these together in the statistical models, but analysed them separately.

To allow for small numbers and unstable rates of hospital admissions and mortality we used random effects models to produce smoothed relative risk maps. To examine the effects of noise we fitted Poisson regression models with an additional random effect term to account for over-dispersion and residual heterogeneity, using the R software (www.r-project.org/) and tested for linear trend across noise categories using the median noise value for each category.

Results

Figure 1 shows the study area; the population (2001 census) was 3.6 million. During 2001-05, 189 226 first episodes of hospital stay in a given year for cardiovascular disease (16 983 stroke, 64 448 coronary heart disease) and 48 347 cardiovascular disease related deaths (9803 stroke, 22 613 coronary heart disease) occurred in the study area (table⇓). Supplementary figures 1 and 2 show the maps of hospital admissions at census output area level and mortality at super output area level, respectively. Only 2% or fewer of the study population lived in areas exposed to the highest category of daytime (>63 dB) or night time (>55 dB) aircraft noise (see supplementary table 1).

The area affected by night time noise was less extensive than that for daytime noise (fig 1). Supplementary figure 3 shows the spatial distributions of the confounder data. Areas with a high proportion of South Asian and black ethnicity population were concentrated in the north eastern and eastern part of the study area, respectively, which were also areas with higher deprivation and higher risks of lung cancer. Within the London area, higher levels of PM_{10} were found in the eastern part towards central London; distributions of both PM_{10} and road noise differed from that of aircraft noise (supplementary figure 3 and figure 1). Correlations between aircraft noise and potential confounders are shown in supplementary table 2 where τ=1 denotes perfect positive correlation and τ=−1 denotes perfect negative correlation. Correlations between confounders and aircraft noise were all ≤|0.30|. In the London boroughs, aircraft noise was modestly correlated with PM_{10} (τ=−0.2 for daytime noise and τ=-0.3 for night time noise) but not with road traffic noise (τ ≤0.02).

Hospital admissions

Figure 2⇓ and supplementary table 3 show the results for hospital admission for daytime and night time noise adjusted for age and sex, and with additional adjustment for ethnicity, deprivation, and the smoking proxy. For each of stroke, coronary heart disease, and cardiovascular disease the pattern was of increasing risk of admission with increasing aircraft noise, and all linear tests for trend were statistically significant (P<0.001 to P<0.05). The risk of coronary heart disease in particular, and to a lesser extent cardiovascular disease, was noticeably reduced by adjustment for multiple confounders, in particular South Asian ethnicity.

In multiple adjustment models, for daytime aircraft noise (>63 dB *v* ≤51 dB) the relative risk for stroke was 1.24 (1.08 to 1.43), for coronary heart disease was 1.21 (1.12 to 1.31), and for cardiovascular disease was 1.14 (1.08 to 1.20). Corresponding relative risks for night time noise (>55 dB *v* ≤50 dB) were 1.29 (1.14 to 1.46), 1.12 (1.04 to 1.20), and 1.09 (1.04 to 1.14). Results using the same categories for daytime as for night time noise (supplementary table 3) suggested higher relative risks for night time noise.

Mortality

Figure 3⇓ and supplementary table 4 show the results for mortality for daytime and night time noise. The relative risks of mortality were numerically similar to those for hospital admissions at the higher noise levels, although confidence intervals were wider, reflecting the smaller numbers of events. In multiple adjusted models, for daytime aircraft noise (>63 dB *v* ≤51 dB) the relative risk for stroke mortality was 1.21 (95% confidence interval 0.98 to 1.49), for coronary heart disease was 1.15 (1.02 to 1.30), and for cardiovascular disease was 1.16 (1.04 to 1.29). The corresponding relative risks for night time aircraft noise (>55 dB *v* ≤50 dB) were 1.23 (1.02 to 1.49), 1.11 (0.99 to 1.24), and 1.14 (1.03 to 1.26). Results using the same categories for daytime as for night time noise (supplementary table 4) suggested higher relative risks for night time noise. Tests for linear trend across noise categories in the fully adjusted models were significant (P<0.05) for daytime noise and coronary heart disease but not for stroke or cardiovascular disease, nor night time noise.

Sensitivity analyses

Results were materially unchanged with additional confounder adjustment for particulate air pollution and road traffic noise in the 12 London boroughs (data not shown).

Discussion

In this small area study covering a population of 3.6 million people living near Heathrow airport in London, we identified significant excess risks of stroke, coronary heart disease, and cardiovascular disease, especially among the 2% of the population affected by the highest levels of daytime and night time aircraft noise.

Strengths and weaknesses of this study

Strengths of this study include the large general population sample, inclusion of both incident events (hospital admissions) and mortality, and wide range of aircraft noise levels, providing sufficient statistical power to detect modest associations. Common to some other epidemiological studies,[11 12] we analysed aircraft noise separately from other transport noise as it is currently unclear whether noise may be additive or whether aspects of noise such as sound frequency and number and duration of noisy events may be important. Limitations include inability to adjust for confounders at individual level. We were able to adjust at small area level for ethnicity, deprivation, and a smoking proxy (and additionally for particulate air pollution and road traffic noise for a subset of 2.6 million people), but we did not have access to individual level information on confounders such as smoking; therefore results at the area level may not be applicable to individuals (ecological fallacy). Admissions for coronary heart disease and to a lesser extent for cardiovascular disease were particularly affected by adjustment for South Asian ethnicity, which itself is strongly associated with risk of coronary heart disease[28]; hence these risk estimates should be interpreted cautiously. We restricted our hospital admission analyses to the first admission within one calendar year; as we did not link across years it is possible that some may be readmissions if they occurred in different calendar years. However, point estimates at higher noise levels were similar for mortality and hospital admissions, making it less likely that this was an important source of bias.

We examined exposures to aircraft noise in 2001 and health outcomes in 2001-05. We were unable to distinguish between short and longer term effects of noise in the present study and this needs to be examined in further research. Some studies[9 12] have suggested larger effect estimates with longer duration of residence, but this may reflect exposure misclassification among more recent residents. Our data on noise exposure are left censored because of concerns about the accuracy of noise models at low levels. It is difficult to determine the resulting misclassification bias; this may also have affected the size of our risk estimates by restricting the range of noise levels across which effect sizes were estimated. A further potential source of bias is that we did not have information on migration in and out of the study areas.

Possible explanations and implications in the context of previous studies

Potential for causality of the observed associations needs to be considered in the context of previous studies, including consideration of biological plausibility and coherence. Much of the research effort concerning adverse effects of noise on cardiovascular health has focused on effects on blood pressure and risk of hypertension, hypertension being the leading cause of stroke and a major risk factor for heart disease.[29] Acute exposure to noise activates the neuroendocrine system, leading to short term increases in heart rate or blood pressure, or both[18-30] and in stress hormone levels[31]; neuroendocrine effects are also seen with chronic exposures[17] offering potential mechanisms by which environmental noise may be related to cardiovascular risk. Although these effects have mainly been studied at high exposure levels in the occupational[30 32] or experimental setting,[31] they may also occur at ambient environmental noise levels.[31] In a study conducted near four European airports (including Heathrow), noise disturbance by aircraft noise at night was associated with short term increases in blood pressure of 6-7 mm Hg.[7]

Increased risks of stroke and coronary heart disease would be expected if such physiological changes were to lead to sustained raised blood pressure.[29] A meta-analysis published in 2009[8] of five studies (totalling nearly 45 000 participants) of aircraft noise and risk of long term hypertension gave a pooled relative risk estimate of 1.13 (95% confidence interval 1.00 to 1.28) per 10 dB increase. A subsequent study of approximately 5000 adults in Sweden found long term effects on hypertension risk only in subgroup analyses, but half the study population had a family history of diabetes, which may affect generalisabilty.[5]

The previous literature concerning aircraft noise and cardiovascular disease and mortality is sparse and not fully consistent. In a cross sectional study of people living near seven European airports (including Heathrow), a significant association was observed between night time average aircraft noise and self reported heart disease and stroke (odds ratio 1.25, 95% confidence interval 1.03 to 1.51) in those who had been living in the same place for 20 or more years.[12] A census based study of 4.6 million adults aged more than 30 years in Switzerland reported an association with mortality from myocardial infarction in those exposed to the highest level of aircraft noise and who had lived at least 15 years in their place of residence; no associations were seen with stroke or cardiovascular mortality.[9] A study of adults aged 45-85 years living in Vancouver, Canada[10] did not find associations of aircraft noise with coronary heart disease mortality, neither did a population based study of about 57 000 adults aged 50-64 years in Denmark with stroke mortality.[11] These previous studies had lower population exposures to aircraft noise than in London.

As with our findings for aircraft noise, significant associations have been reported for road traffic noise and heart disease[10-35] and stroke.[11] A meta-analysis of 24 population studies of road traffic noise found a dose-response association with hypertension,[36] with a combined odds ratio of 1.03 (95% confidence interval 1.01 to 1.06) per 5 dB increase of road traffic noise, in the range 45-75 dB.

We were unable to distinguish between night time and daytime noise as they were highly correlated and so their effects could not be differentiated. More research is needed to determine if night time noise that disrupts sleep may be a mechanism underlying observed associations.[2]

Conclusions

How best to meet commercial aircraft capacity for London and other major cities is a matter of active debate, as this may provide major economic benefits. However, policy decisions need to take account of potential health related concerns, including possible effects of environmental noise on cardiovascular health. Our results suggest that high levels of aircraft noise are associated with an increased risk of stroke, coronary heart disease, and cardiovascular disease. As well as the possibility of causal associations, alternative explanations should be considered. These include the potential for incompletely controlled confounding and ecological bias, as we did not have access to individual level confounder data such as ethnicity and smoking. Further work to understand better the possible health effects of aircraft noise is needed, including studies clarifying the relative importance of night time compared with daytime noise, as this may affect policy response.

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Contributors: PE and ALH with MB, LF, SF, KdH, DF, LB, and SR conceived and designed the study. MB, LF, SF, KdH, DF, REG, LB, JG, and SB were involved in data extraction and preparation. JG, KdH, and DF were responsible for the Geographical Information System analyses. JG, KdH, and HEL interpreted the aircraft noise data. LF and MB with REG and CP carried out the statistical analyses, supervised by PE, ALH, SR, and NB. The analyses were interpreted by PE, ALH, MB, LF, NB, SR, HEL, and JG. ALH and PE drafted the initial report; all coauthors revised the report and approved the final version. MB and LF contributed equally to this paper and are joint second authors. PE is the guarantor of this paper.

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Ethical approval: The study was commissioned by the Department of Health in England; ethical approval was obtained from the National Research Ethics Service reference 12/LO/0566 and the Imperial College Research Ethics Committee.

Data sharing: Data are available from the data providers on application with appropriate ethics and governance permissions, but we do not hold data provider, ethics, or governance permissions to share the dataset with third parties.

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What is already known on this topic

Few studies have examined aircraft noise and risk of incident or fatal cardiovascular disease or stroke

Previous studies have found an increased risk of hypertension associated with aircraft noise and increased risk of hypertension, stroke, and coronary heart disease with road traffic noise

These findings are consistent with those from studies of occupational noise exposure, and experimental studies examining short term effects of noise on the cardiovascular system

What this study adds

Areas with high levels of aircraft noise related to Heathrow airport in London had increased risks of stroke, coronary heart disease, and cardiovascular disease

Interpretation should consider not only causal associations but also possible alternative explanations such as residual confounding and ecological bias

Table

Table 1| Summary statistics for population data (2001) and health data (2001-05)

Variables	Total	Mean (SD) by geographical unit, 2001	
		Super output area (n=2378)	Census output area (n=12 110)
Population (2001 census)	3 591 719	1510 (140)	297 (74)
Mortality:			
Stroke (I61, I63, I64)*	9803	4 (4)	—
Coronary heart disease (I20-I25)*	22 613	10 (6)	—
Cardiovascular disease (Chapter I)	48 347	20 (12)	—
Hospital admissions:			
Stroke (I61, I63, I64)*	16 983	—	1 (2)
Coronary heart disease (I20-I25)*	64 448	—	5 (4)
Cardiovascular disease (Chapter I)*	189 226	—	16 (8)

*ICD-10 codes (international classification of diseases, 10th revision).

Figures

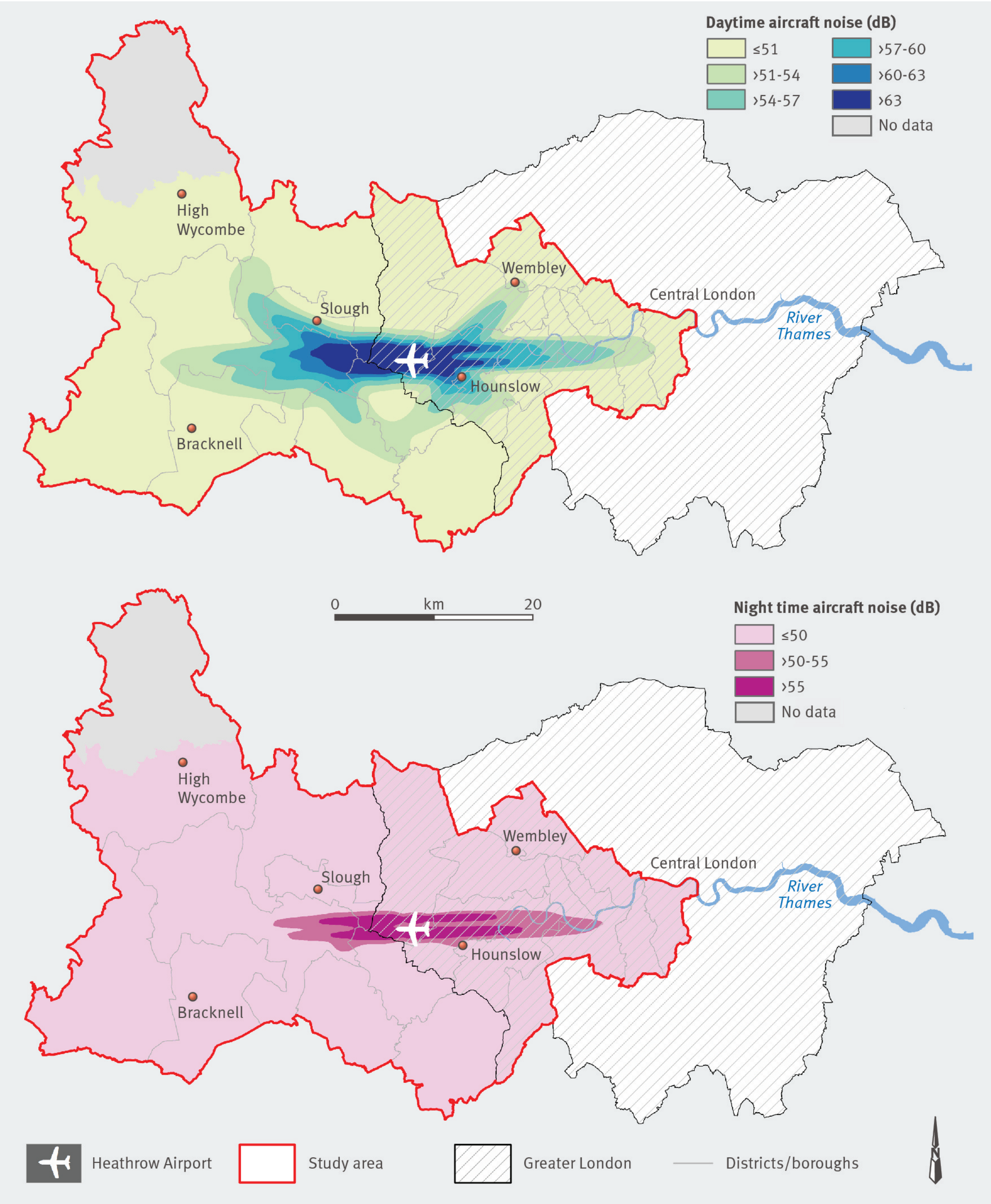

Fig 1 Contextual maps of study area and Heathrow airport showing (top) London boroughs and districts outside London overlaid with the 2001 annual average aircraft daytime (7 am-11 pm, $L_{Aeq,16h}$) noise contours; (bottom) annual average night time noise contours (11 pm-7 am, L_{night})

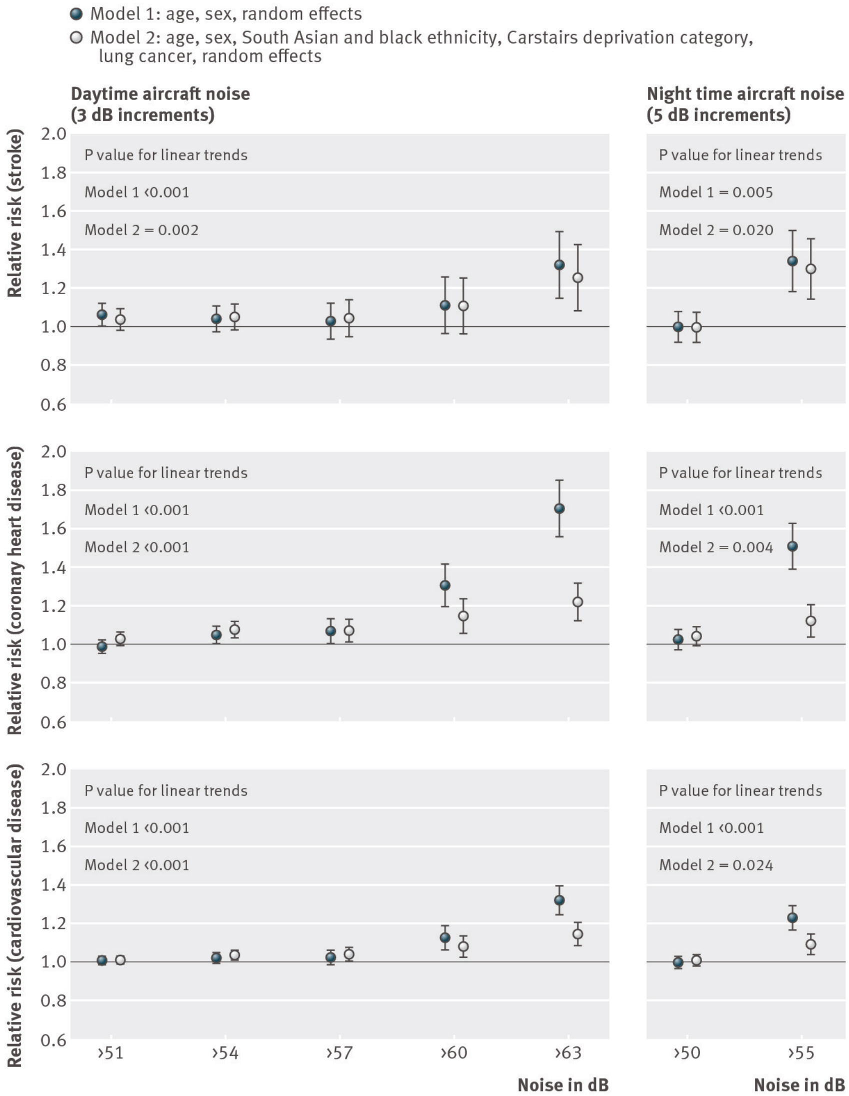

Fig 2 Relative risks (95% confidence intervals) for associations between hospital admissions for stroke, coronary heart disease, and cardiovascular disease in 2001-05 and annual population weighted average daytime aircraft noise (relative to ≤51 dB) and night time aircraft noise (relative to ≤50 dB) in 2001, census output areas

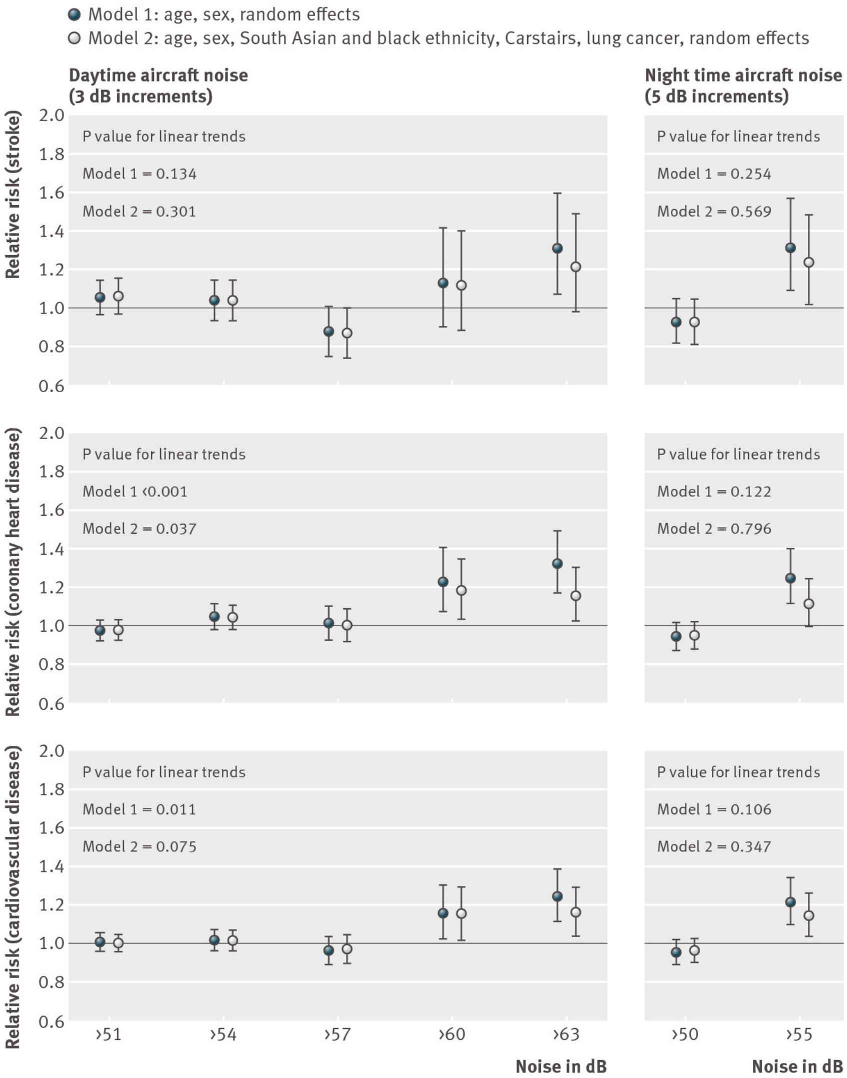

Fig 3 Relative risks (95% confidence intervals) for associations between mortality from stroke, coronary heart disease, and cardiovascular disease in 2001-05 and annual population weighted average daytime aircraft noise (relative to ≤51 dB) and night time aircraft noise (relative to ≤50 dB) in 2001, super output areas

Environmental Research and Consultancy Department

Civil Aviation Authority

ERCD REPORT 0908

Aircraft Noise and Children's Learning

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Summary

This report is a literature review of the research into the effects of aircraft noise on children’s learning and cognition. The primary cognitive processes that are examined in relation to aircraft noise are episodic memory, semantic memory, sustained attention and reading comprehension. The review includes early work in this area from the 1970s, to the most recent studies. Key studies are described, along with suggestions for future research.

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Glossary of Terms

A-weighting A frequency weighting that is applied to the electrical signal within a noise-measuring instrument as a way of simulating the way the human ear responds to a range of acoustic frequencies.

Adrenaline Also referred to as Epinephrine. A hormone and neurotransmitter and member of the catecholamine family, which, when released increases the response of the sympathetic division of the Autonomic Nervous System.

Cortisol Hormone produced by the adrenal gland that is associated with stress responses, increasing blood pressure and blood sugar and reducing immune responses.

dB Decibel units describing sound level or changes of sound level.

dBA Levels on a decibel scale of noise measured using a frequency dependent weighting, which approximates the characteristics of human hearing. These are referred to as A-weighted sound levels.

L_{eq} Equivalent sound level of aircraft noise, often called equivalent continuous sound level. L_{eq} is most often measured on the A-weighted scale, giving the abbreviation L_{Aeq}.

Noradrenaline

Also known as Norepinephrine. Part of the catecholamine family, with dual roes a hormone and neurotransmitter. A stress hormone, along with adrenaline, noradrenaline also underlies the fight-or-flight response, directly increasing heart rate, triggering the release of glucose from energy stores, and increasing blood flow to skeletal muscle.

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1. Introduction

1.1 The effects of aircraft noise have been shown to have implications for sleep disturbance (Basner, 2004; Griefahn, 2000) and cardiovascular effects during sleep (Spreng, 2002; Di Nisi, 1990), and although the effects of transportation noise have been studied during waking hours in adult populations, there are also important implications for the impact of aircraft noise on children's learning and cognitive performance. This review aims to describe the documented effects of aircraft noise on children's development and learning abilities, and suggests potential areas for future work in this area.

1.2 The primary cognitive processes that are examined in relation to aircraft noise are episodic memory, semantic memory, sustained attention and reading comprehension. Episodic memory refers to the memory of people, places, times, events and other conception-based knowledge in relation to an experience. It can be thought of as an autobiographical memory, which is personal to the individual. Semantic memory refers to the memory of meanings, understandings and other concept-based knowledge that is unrelated to experiences. It is the conscious recollection of factual information and general knowledge about the world that is thought to be independent of context and personal experience. Sustained attention refers to a vigilance state that requires attention to be maintained on a focus over a period of time, without lapsing.

1.3 Although there is a wealth of literature on noise and children, the aim of this review is to describe the results of work conducted specifically on aircraft noise and children's cognition.

2 Early Work on Aircraft Noise and Children's Learning

2.1 The early work into this area began in 1975, when Ando *et al* examined the effects of aircraft noise on a simple search and addition task on 1144 elementary school pupils living around an airport, and in a quite area in Kobe, Japan. The conditions of no stimulus sound were compared to that of jet stimulus of 90 ± 5dBA. In terms of performance, those children from relatively noisy areas showed occasional short periods of substantially slower than their average rate of work. When working in continual noisy rather than quiet conditions, these differences did not exist, and the results were independent of gender and attitudes of the children towards aircraft noise.

2.2 There is always a conflict between the pros and cons of laboratory studies versus field study settings. Although laboratory studies allow for detailed and careful manipulation of specific parameters, and a higher degree of control over extraneous confounding variables, field settings offer the opportunity to explore the effects of noise within people's homes, following their usual schedule and with possible habituation to aircraft noise.

The Los Angeles Study

2.3 Cohen *et al* (1980) argued that there needed to be interplay between the two study types, and that maximum understanding of the impact of environmental variables could be achieved by combining both designs. The authors presented the results from an individual testing procedure in a field setting. A matched-group design was used to allow the study of children attending the four noisiest elementary schools around Los Angeles International Airport.

2.4 The peak sound recordings in the schools reached 95dbA, with over 300 over-flights each day (approximately one every 2.5 minutes during school hours). Three schools (in quiet areas) were matched with the experimental schools for a range of variables such as grade levels, ethnic and racial distribution of children, percentage receiving state aid, and occupation and education levels of parents.

2.5 The study centred on the after-effects of noise exposure, therefore all tasks and questionnaires were administered in a quiet area (a noise-insulated trailer parked outside the school). Children for all noise-impacted third and fourth-grade classrooms in each noise school as well as those children from an equal number of classrooms in quiet areas were included.

2.6 The overall mean peak for classrooms in noisy areas were 74dBA and in quiet schools it was 54dBA, with the highest readings at 95dBA and 68dBA, respectively. The results were consistent with laboratory studies, in that children from noisy schools had higher blood pressure than those from quiet schools. Children in noisy schools were more likely to fail on the cognitive task and were more likely to give up before the allocated time to complete the task was allowed. The authors suggested that this might implicate increased helplessness in those children exposed to higher noise levels.

2.7 Cohen (1981) reported data from the Los Angeles Noise Project, a longitudinal study that assessed the impact of aircraft noise on elementary school children. The design was to investigate the course of adaptation and to assess the impact of a noise-abatement intervention on a variety of physiological, cognitive, and motivational measures. The report referred to the results from an extension of the study described above (Cohen, 1980). The matched groups were the same but this report described data collected in the summer following the original data collection. Architectural interventions were installed in 43% of the noisy school classrooms, which resulted in a substantial decrease in noise levels in treated rooms. Following one year after the original testing, children who were still enrolled at the schools were retested on the original measures. The study aimed to assess:

- Whether children retested one year later continue to show effects found during the first session, or do they adapt to the noise over the one-year period?

- The effects of noise abatement interventions in the classroom on various measures of health and behaviour.

2.8 The data established the stability of the original results (Cohen *et al* 1980), in terms of highlighting the effects of motivational and physiological mechanisms that were consistent with the effects found in laboratory settings. The data presented established the stability of these effects over time and reinforced the previous interpretation that children do not adapt to noise over time.

2.9 Noise abatement was found to be partially effective, with the "important school achievement" measure showing some improvement for children in noise-abated classrooms, and had a small improvement effect on cognitive performance, children's ability to hear their teachers, and school achievement.

3. Aircraft Noise and Children's Learning in the 1990s

3.1 Chen and Chen (1993) looked at the effects of aircraft noise on the hearing and auditory pathway function of school-aged children. 228 students attending a school near an airport in Taiwan were compared to 151 students attending a school further away from the airport. Measurements of hearing ability between the two groups were compared, and children from the school under the flight path were found to have significantly worse hearing than those attending school further away. Audiometry and brainstem auditory evoked potentials (BAEP) were compared between the two groups, but there were no significant differences found. The authors suggested the results indicated that central transmission is not affected in children that have been exposed to aircraft noise for several years. The results showed a significant association between aircraft noise and exposure and prevalence of noise-induced hearing loss, and although damage to peripheral cochlear organs was confirmed in school-aged children, involvement of the central auditory pathway could not be demonstrated.

The Munich Study

3.2 Evans *et al* (1995) investigated at the effects of chronic noise and psychological stress on children, using neuroendocrine indices alongside cardiovascular measures. Performance was also measured in terms of speech perception, attention, choice reaction time and visual search (an attention-orientated task). 135 third and fourth graders, with a mean age of 10.78 years who were living in either a high noise-impact urban neighbourhood (24-hr L_{eq}= 68.1dBA; peak=79.8dBA) surrounding Munich International Airport, or in a quiet neighbourhood (24-hr L_{eq}=59.2dBA; peak=69.0dBA) in Munich. The groups were matched for socioeconomic status, occupation within the households, parental education, and family size. Blood pressure, twelve-hour overnight urinary adrenaline and noradrenaline and cortisol levels were assessed. A battery of tests to include measures of attention, memory and reading ability measured cognitive performance. In addition, motivation, annoyance and quality of life were assessed.

3.3 Testing was conducted in a sound-attenuated trailer at the children's school. The results showed that there was a difference in psychophysiological variables between groups. Overnight levels of adrenaline and noradrenaline were significantly different between those children chronically exposed to aircraft noise and those unexposed. Cortisol levels were not significantly different between groups. A significant difference was also observed in the systolic blood pressure among children chronically exposed to aircraft noise, compared to those in a quieter environment, although no difference was reported in diastolic blood pressure.

3.4 The two noise groups did not differ in terms of performance on an attention task, or with regard to reaction times. However, in the long-term memory recall task, children from noisy areas performed worse than their counterparts, and there were also slight reductions in working memory span in the children from the higher noise area. In terms of reading ability, children from noisy areas made significantly more errors on the German standardised reading test than children from quiet communities.

3.5 As has been reported by Cohen (1981), the findings showed that children from noisy locations persisted less than children from quiet areas, on an insolvable puzzle task, suggesting that there is a degree of helplessness associated with this group. With regard to annoyance measures, children living in noisier areas were significantly more annoyed by noise in their communities than children in quieter areas.

3.6 This study was important in being the first of its kind to integrate measures of physiological markers of stress with tests for cognitive performance in children exposed to chronic aircraft noise. The results raised questions as to whether the effects of aircraft noise in children persist or continue to widen with increased aircraft noise, and whether the deficits exhibited are reversible in the affected populations. The authors suggested that children might cope with adverse noise by developing coping strategies such as 'tuning out' ambient noise, which may have implications for language acquisition and speech processing.

3.7 Evans and Maxwell (1997) followed this idea up and examined the effect of chronic noise exposure on reading deficits in children, specifically speech perception and phoneme comprehension. The authors hypothesised that the reason chronic noise exposure interferes with the development of reading skills is because it disrupts language acquisition. A secondary aim was to examine whether the link between noise exposure and reading deficits is the result of chronic or acute noise exposure. Acute interference occurs during the actual testing sessions, whereas the term chronic refers to long-term exposure to noise.

3.9 116 fist and second graders from two elementary schools in New York participated in the study. The target school was within the 65L_{eq} flight contour of a major New York metropolitan airport, with the control school located in a quiet neighbourhood.

Both were matched for percentage of children receiving subsidised lunches, ethnicity, and the percentage of pupils with English as a second language.

3.10 Reading skills were assessed, using the Woodcock reading subscales, along with language acquisition and speech perception. An embedded phoneme test was also given to each participant. The results showed that chronic noise exposure is significantly correlated with reading scores, and secondly speech perception was related to reading linkage. Speech perception and reading ability were also correlated. Interestingly, the mother's educational levels were correlated with noise exposure and with reading ability, however noised remained a significant predictor of reading scores after statistically controlling for mother's education. Income was not significantly correlated with either measure. Noise exposure affected speech perception, which in turn affected reading ability, yet even when speech perception was partialed out of the analysis, noise remained a significant contributor to reading ability.

3.11 The authors concluded that the association between noise exposure levels and reading was due to chronic exposure and not to acute inference by noise during the actual test session. There was also partial support for the hypothesis that language acquisition is an underlying, intervening mechanism accounting for the noise-reading deficit link. Evans *et al* also made the point that social and interpersonal processes should also be considered in the future, such as noise disrupting actual teaching time, the behaviours of teachers and primary caregivers, and also the effect of noise as an irritant, thereby possibly contributing to increased hostility and aggressive behaviours. They suggested that more rigorous, longitudinal studies are necessary, coupled with further analysis of underlying cognitive and social processes that can contribute to the adverse effects of chronic noise exposure of health and children's development.

3.12 Evans *et al* (1998) conducted a longer-term study over a two-year period, and assessed the physiological responses in children to chronic noise exposure. The timing of the study was such that a natural experiment was created due to the opening of the new International Airport in Munich. Resting blood pressure, overnight levels of neuroendocrine hormones, and quality of live were measured over a 2-year period among elementary school children in the flight paths, before and after the opening of the airport. Subjects were 217 third and fourth grade children (mean age 9.90 years) living either close to Munich International Airport or in nearby communities outside the noise impact zone of the new facility. Following the opening of the airport L_{eq} was 62dBA, with an L_{01} (the dBA) level exceeded 1% of the time over the sampling method i.e. 24 hours) of 73dBA in the noise-impacted communities. In the quiet communities at the same time, dBA L_{eq} was 55, with a dBA L_{01} of 64. Prior to the opening of the airport, dBA L_{eq} was 53 with a L_{01} of 63 in the noisy areas, and noise levels were comparably low in the comparison areas (dBA L_{eq} = 53; dBA L01 = 64). The matched samples did not differ in terms of socioeconomic status, type of occupation, parental education, or family size. Again, testing was performed in a noise-proof trailer outside the schools, and blood pressure, adrenaline and noradrenaline, and cortisol levels were measured. Data were collected 6 months prior to the opening of the airport (Wave 1), 6 months after opening (Wave 2) and again 18 months after opening (Wave 3).

3.13 Blood pressure increased in the noise-impacted areas after Wave 1, and a sharp increase in adrenaline and noradrenaline levels were seen in those children living under the flight path following Wave 1, compared to the children in quieter areas. Cortisol levels were unaffected. Quality of life decreased significantly in the noise-impacted areas in after Wave 3, but remained stable in the quieter areas. The authors concluded that in young children chronic noise exposure appeared to cause increased psychological stress, as measured by cardiovascular, neuroendocrine, and affective indicators and these effects occur even among children who suffer no detectable hearing damage while living in the immediate vicinity of an airport. Bullinger *et al* (1999) also reported that motivational deficits were seen in those children exposed to aircraft noise in this study, compared to children living in quieter areas, as assessed by the number of attempts made to solve an insolvable puzzle task at the three time points.

4 Recent studies

The West London Schools Study

4.1 In 2001, Haines *et al* published the findings of a study into chronic aircraft noise exposure, stress responses, mental health and cognitive performance in 340 school children aged 8-11 around London Heathrow Airport. Children in four schools exposed to outdoor L_{eq}>66dBA were matched with those in lower noise areas, with outdoor L_{eq}<57dBA. The results indicated that chronic noise exposure was associated with higher levels of noise annoyance and impaired reading comprehension, but there was no effect on mental health problems or elevated cortisol levels. The authors concluded that the association between aircraft noise exposure and decrements in reading comprehension could not be accounted for by the mediating role of annoyance, confounded by social class, deprivation, main language or acute noise exposure.

4.2 The results of a follow-up study to this one were also published in 2001 by Haines *et al*, and included the results found a year later to the original study. It was hypothesized that:

- The effects of aircraft noise exposure on reading comprehension and noise annoyance at baseline would be replicated in the same sample of school children who were tested at follow-up a year later
- Chronic aircraft noise exposure produces an increased delay in reading comprehension over a period of a year, compared to pupils not exposed to aircraft noise during that year

- Chronic aircraft noise exposure in children would be associated with impairments in sustained attention and high levels of self-reported stress.

4.3 Sustained attention was tested as a mediating factor in the association between noise exposure and reading impairment. The initial study was conducted in 1996, with the follow-up study a year later in 1997. The initial response rate was 340 participants, with 275 completing the follow-on. Testing procedures were the same in each study, and were carried out inside classrooms to assess indoor sound levels of aircraft noise during testing, using a sound level meter on a tripod and a portable DAT recorder.

4.4 The results indicated that chronic exposure to high levels of noise exposure was associated with higher levels of annoyance, perceived stress, and poorer reading comprehension ability. Aircraft noise exposure was also associated with deficits in sustained attention. Over time, performance in reading comprehension was significantly different between the high and low noise groups, however following adjustments for age, main language spoken, and deprivation the difference failed to reach significance. The authors suggested that this might have been due to the reduced sample size in the follow-on study, and therefore a reduction in statistical power. The same result was found for annoyance, with significance failing to be reached after adjustments. Sustained attention did not explain the significant association between aircraft noise exposure at school and reading comprehension, as the main effect was not altered following adjustment for sustained attention.

4.5 The main results of this study can be summarised in the following points:

i) The associations between chronic aircraft noise and reading comprehension, noise annoyance and mental health were replicated at follow-up.

ii) The within-subjects analyses indicated that children's development in reading comprehension might be adversely affected by chronic aircraft noise exposure. Noise annoyance remained constant over a year with no strong evidence of habituation, and the effect of noise on children's progress in reading over time may be influenced by sociodemographic factors.

iii) The association between aircraft noise exposure and reading comprehension could not be accounted for by the sustained attention mediation hypothesis.

iv) Chronic aircraft noise exposure was associated with poorer sustained attention in children.

v) Chronic aircraft noise exposure was associated with higher levels of self-reported stress in children.

4.6 Although the results of this study were not conclusive, they did provide evidence to suggest that noise exposure affects child cognition, and stress responses and these effects do not habituate over time. The authors suggested that further research should examine the long-term implications of the effects of noise, and an exploration of the underlying mechanisms involved should be conducted.

4.7 In their review of the three field studies conducted by Cohen *et al* (1980, 1981), Evans *et al* (1995, 1998) and Haines *et al* (2001), Matheson *et al* (2003) summarised the main findings as previously discussed, and concluded that despite occurring in different parts of the world (Los Angeles, Munich and London), a number of findings were consistent in terms of the effects reported. Matheson *et al* concluded that it appeared that children chronically exposed to high levels of aircraft noise consistently experienced raised annoyance levels, and raised blood pressure. Evidence also suggested that there are increased stress response levels, in terms of neuroendocrine measures such as adrenaline and noradrenaline levels, in children exposed to chronic aircraft noise. The studies also provided evidence that motivation may be impaired and noise-exposed children may experience a sense of helplessness. In terms of cognitive performance, the studies suggested that chronic noise exposure affected reading ability and attention, along with some evidence for effects on memory.

4.8 Matheson *et al* suggested that an important direction for future research should be to examine the long-term effects of aircraft noise i.e. do the results persist, become more severe, or whether children are able to adapt to noise and catch-up with their non-noise exposed counterparts. It was also suggested the question of dose-response relationships should be addressed, i.e. at what levels of noise do effects begin to appear?

4.9 Hygge (2003) looked at the effects of noise in the classroom on 1358 children aged 12-14 years. They were tested for recall and recognition of a text exactly one week later. Single and combined noise sources were presented for 15 minutes at L_{eq} 66dBA, and single source presentations of aircraft and road traffic noise were also presented at 55dBA. A strong effect of noise on recall was found, along with a smaller, but significant effect on recognition. Aircraft noise and road noise impaired recall at both noise levels, with train and verbal noise having no effect. Some of the pair-wise combinations of aircraft noise with train or road traffic, with one as the dominant source, also interfered with recall and recognition.

4.10 Haines *et al* (2003) reported the qualitative responses of children to environmental noise in two studies. The first was the Millennium Conference Study, which used focus group interviews with an international sample, unselected by exposure. 36 children aged 10-13 years, from 12 countries took part, with approximately 12 children in each group. The second study was the West London Schools Study (Haines *et al* 2001), which involved individual interviews, conducted with a purposively selected sample exposed to aircraft noise. 18 children were interviewed from 10 schools near Heathrow Airport. Nine children were from schools exposed to high levels of aircraft noise (L_{eq}>63dBA) and nine were from schools exposed to lower levels of aircraft noise (L_{eq}<57dBA) The aims of the studies were to explore children's:

- Perception to noise exposure
- Perceived risk of and attitudes towards noise pollution

- Coping strategies
- Annoyance response

4.11 In the Millennium Conference Study, children listed the most frequent noises they heard as being made by people, e.g. screaming and crying, followed by noise made by animals and then traffic noise. Negative emotions were associated mainly with traffic noise, industrial noise, sirens, alarms etc. Positive emotions were linked to natural sounds such as the wind and household noises such as washing up, fans and the television. Many children felt that the amount of control they had over noise pollution depended on the source of the noise. The majority (n=19) felt in control of noise made in their own homes, but did not feel as though they had control over noise generated outside their homes such as planes flying overhead, or traffic noise. In terms of coping strategies, the most popular was by blocking out the unwanted noise, by wearing headphones or playing music. The second most reported strategy was by 'thinking about something else', and thirdly to take action such as telling someone to turn the noise down, or off. Two thirds of the sample wanted to change their environment and make it quieter, whilst a third thought it was acceptable at the present level.

4.12 In the West London Schools Study, half of the high aircraft noise exposed children (n=5) and a third of the low aircraft noise exposed children (n=4) expressed that there were aspects of their school environment that made them feel stressed. Four of these claims related to environmental stressors, two concerning aircraft (high noise), one cars (high noise) and one trees (low noise). A negative attitude was expressed towards aircraft noise by more low noise exposure children (n=7) than high noise exposure children (n=4). A majority of the high noise group expressed they were disturbed while thinking or doing schoolwork. In terms of coping strategies, covering the ears was the most popular method for dealing with aircraft noise for both the high and low noise populations. Doing nothing and ignoring it were the second and third most popular strategies from both noise groups. A negative emotional reaction to aircraft noise was voiced by all low noise (n=9), and most high noise (n=7) children. The children defined annoyance as, 'disturbing, being bothered, annoyed, feeling stressed out and upset, and even fear'. This emotional response of children was consistent with adult reactions and the authors suggest that child noise annoyance is the same construct.

4.13 A limitation of these studies were the relatively small sample sizes, and it was suggested that future research should focus on an international sample of children, with larger sample sizes, longer in-depth interviews and a measure of cultural expectation of ideal noise exposure in environments should be included.

4.14 Lercher *et al* (2003) examined ambient noise and cognitive processes among primary school children. Although this work did not focus on aircraft noise, the study showed interesting findings relating to the effect of noise on children's developmental cognitive process, in particular memory, which may be pertinent to aircraft noise also. 123 primary school children (mean age 9.7 years) were selected from a large, representative sample of children living in the lower Inn Valley of Tyrol, Austria. The sub-sample was selected on the basis of ambient noise exposure at the child's home. In this study the noise sources were road and rail, with one half of the sample living in neighbourhoods below 50dBA and the other half living in areas above 60dBA. Data was collected individually in a mobile, sound-attenuated laboratory, and consisted of annoyance, psychological and physiological stress, and cognitive processes.

4.15 No effect of noise exposure was found on visual search performance, although the authors did suggest that the overall low error rates might mean this task was too easy. Chronic noise exposure was significantly related to both intentional and incidental memory, with intentional, explicit recall for the target text being significantly better in the low noise group than the high noise group. Incidental, free recall was impaired by chronic noise exposure, as was recognition memory. The authors suggested that chronic noise exposure has a detrimental effect on the developmental cognitive processes in children, particularly with regard to explicit or intentional memory. They suggested that a longitudinal study should be addressed in future research, allowing for each child to serve as his or her own control with changes in noise exposure. Such designs provide stronger causal inference and yield greater statistical power due to the lack of unexplained variance due to individual differences.

4.16 Interestingly, Matsui *et al* (2004) published the results from the West London Schools Study on children's cognition and aircraft noise exposure at home shortly after the findings by Lercher *et al.* Children from 20 schools around Heathrow Airport took part, ten from high-aircraft noise urban areas (L_{eq}>63dBA) and ten from low aircraft noise-impact urban areas. (L_{eq}<57dBA). The cognitive performance tests were group-administered in the classrooms, and parents were given questionnaires enquiring about the children's health and socioeconomic background, which may have affected performance. Reading comprehension was assessed, along with long term memory recall and recognition, and sustained attention. Confounding factors were measured by the calculation of a household deprivation score, incorporating: income, home tenure, car ownership, employment, status, central hearing, social class and household crowding. The mother's educational level was also asked.

4.17 The results showed significant trends of dose-response relationships with noise level on immediate recall, and delayed recall after adjustment for age, sex, deprivation score, language spoken at home, mother's education level and school. The other three measures (reading mean score, reading on difficult questions and sustained attention) did not show a significant dose-response relationship, however the odds ratios on the other three outcomes were greater than one in the highest noise groups. The authors concluded that there was a dose-response relationship between noise level at home and the ratio of pupils having decreased scores on delayed and immediate recall after adjustment for age, sex, spoken language at home, deprivation, mother's education level and school. It was suggested that further memory studies were needed to clarify and confirm the effect of aircraft noise on this particular cognitive process.

4.18 In the same year, Bowman (2004) looked at the effects of meaningless speech and traffic noise on episodic and semantic memory in 96 children aged 13-14 years. Equal groups of 32 pupils were randomly assigned to a silent or two noise conditions (meaningless irrelevant speech, or traffic noise) at L_{eq} of 66dBA in each of the noise conditions. Effects of noise were found in terms of impairments from meaningless speech on recognition and cued recall of a text in episodic memory and of word comprehension in semantic memory. There were no significant interactions between road noise and memory processing, although female pupils performed better on episodic and semantic memory tasks but this result did not interact with noise.

4.19 The psychosocial effects of community noise were examined in Macedonia by Ristovska *et al (*2004). Two groups of 10-11 year old children living in areas of 8hour L_{eq} >55dBA (n=266) and in areas of 8hour L_{eq} <55dBA (n=263) were tested for attention, anxiety and Attention Deficit Disorder. Children in the higher noise areas had significantly decreased attention, decreased social adaptability, and increased opposing behaviour in their relations to other people. There was no correlation between socioeconomic characteristics and the development of psychosocial effects.

The RANCH Project

4.20 One of the largest-scale studies to be conducted on aircraft noise and children's learning over recent years is the RANCH project (Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health), by Stansfeld *et al* (2005). Between April and October in 2002, 2844 children aged 9-10 years were studied in a cross-sectional study from primary schools near Schiphol (Netherlands), Barajas (Spain), and Heathrow. Schools were selected due to their increasing exposure to aircraft and road traffic noise, and were classified by a four-by-four grid of noise exposure in each country. Two schools were randomly selected within every cell to allow the effects of increasing aircraft noise within low traffic noise, increasing road traffic noise within low aircraft noise, and the effects of combinations of aircraft noise and road traffic noise, to be examined. The socioeconomic status of the pupils was matched, as measured by the eligibility for free school meals, and language spoken at home.

4.21 Aircraft noise exposure was assessed by 16h outdoor L_{eq} in the UK, with road traffic noise being assessed by a simplified form of the UK standard Calculation of Road Traffic Noise (CRTN) prediction method, using a combination of information including proximity to motorways, major roads and traffic flow data. Noise assessments were provided by modelled data on road and aircraft noise exposure linked to school locations with geographical information systems, in the

Netherlands. In Spain, the researchers visited the 96 pre-selected schools and made direct measurements of road traffic noise, with aircraft noise being based on predicted contours.

4.22 Cognitive performance was assessed in reading comprehension, using nationally standardised tests, episodic memory (recognition and recall) and sustained attention. Working memory was assessed with a revised version of the search and memory task, and prospective memory was assessed by asking children to write their initials in the margin when they reached two predefined points in two of the tests. Health outcomes and perceived annoyance were assessed by questionnaire, and parents were asked to complete questionnaires on child psychological distress, sociodemographic context variables, environmental attitudes, and noise annoyance.

4.23 Testing occurred in two-hour slots under a standardised protocol, and took place in the morning in each country. In terms of cognitive performance, the results indicated that exposure to chronic aircraft noise was associated with a significant impairment in reading comprehension, and this effect size was consistent across countries. A 5dB increase in aircraft noise was equivalent to a 2-month reading delay in the UK, and a 1-month delay in the Netherlands. No national data was available in Spain. In terms of memory performance, exposure to aircraft noise was associated with a significant impairment in recognition, but not information or conceptual recall. Aircraft noise was not associated with deficits in working memory, prospective memory, or sustained attention.

4.24 Road traffic noise was associated with an increase in the number of scores for episodic memory scales of information and conceptual recall, which was an unexpected finding. No effects of road noise were seen in terms of reading comprehension, recognition, working memory, prospective memory or sustained attention. In terms of health effects, increased exposure to both types of noise resulted in increased annoyance in children, however no effects of aircraft or road noise were seen in terms of self-reported health or mental health.

4.25 The authors suggested that the unexpected finding of increased episodic memory performance in areas of high road noise might require further investigation. This study was cross-sectional in design, but it is suggested that longitudinal studies may provide further insight into the impact of noise on the cognitive developmental systems in children.

4.26 In response to the publication on this study, Smith (2005) suggested that the results may be influenced by the different geographical distribution of children's intelligence by noise exposure level, and that there could be a state-dependent effect occurring, whereby the testing situation may be more typical of everyday conditions for road traffic noise than for aircraft noise. If this was the case, performance would be better in road traffic noise where and chronic exposure match, and would deteriorate for exposure to aircraft noise where acute noise exposure may differ from chronic exposure.

4.27 The authors responded to these points (Stansfeld *et al,* 2005) by clarifying that a brief measure of intelligence was included on the Spanish and UK samples, but this was not included due to the co-linearity of intelligence with the other cognitive measures, and that the school matching procedure would partly control for intelligence as well as socioeconomic status. After further analyses, it was reported that neither exposure to aircraft noise nor road noise was associated with intelligence. The association between aircraft noise and reading comprehension was not changed by further adjustment for intelligence. In addition, running the previous analyses excluding pupils with learning difficulties did not alter the results. In response to the state-dependent comment, the authors explain that the naturalistic design of the study should have allowed for this possibility, and following adjustment for acute noise as measured by two microphones in the classroom, the results remained unchanged.

4.28 Clark *et al* (2006) also reported the results from the RANCH project. In addition to the results reported above, the effect of aircraft noise exposure at home on reading comprehension was also described. In all three countries, aircraft noise at home was highly correlated with the exposure level at school. Increasing aircraft noise at home was also significantly correlated with poorer reading comprehension, but there was no additional effect of home aircraft noise exposure after adjustment for aircraft noise exposure at school. Although in the West London Schools Study, the effect of noise and reading performance was confounded by socioeconomic status, the RANCH project did not produce similar results. The UK sample, despite being of lower socioeconomic status, responded to noise exposure similarly to the more affluent Dutch and Spanish samples, and the authors suggest that socioeconomic factors do not explain the primary effects of noise on reading ability. The authors suggest that an important area to examine in the future would be to assess the relative contribution of home and school noise exposure over a full 24-h period, to cognitive performance.

4.29 It is also noted that the road traffic noise levels were not as high as previous studies, with the annual equivalent levels reaching a maximum of 71dBA around schools. The authors note that the road traffic noise exposure levels at home may also contribute to cognitive performance, and should also be studied alongside exposure at school. It was proposed that the greater effect of aircraft noise on cognition decrements may be due to the intermittent characteristic of aircraft noise, with typically more intense and less predictable noise events causing distraction, compared to the more continuous nature of road noise which may allow children to habituate and not be as distracted. It was suggested that aircraft noise might also produce higher arousal levels, which is more likely to interfere with tasks such as reading comprehension.

4.30 A recent study by Shield and Dockrell (2008) looked at the effects of environmental and classroom noise on the academic performance of primary school children. The aim of the study was to examine the effects of chronic internal and external noise exposure on the standardised test results of children aged 7-11yrs in London primary schools. The tests involved literacy, mathematics and science.

4.31 External noise was found to have a significant negative impact on performance, with a larger effect being seen in older children. The analysis suggested that children are particularly affected by the noise of external effects. Internal classroom noise background levels also significantly affected the test scores. Negative relationships between performance and noise levels were maintained when the data were corrected for socio-economic factors relating to social deprivation, language, and special educational needs.

5. Summary

5.1 This review has aimed to describe the main contributions in the field of aircraft noise and cognitive ability in children. The results are not completely in agreement, but there is evidence to suggest that chronic aircraft noise has a deleterious effect on memory, sustained attention, reading comprehension and reading ability. Early studies highlighted that aircraft noise was also implicated in children from noisy areas having a higher degree of helplessness i.e. were more likely to give up on difficult tasks than those children in quieter areas. This motivational decrement was reported in various studies, and it was suggested that this should be an area for future research over a longitudinal study protocol.

5.2 Reports often indicated that children exposed to chronic aircraft noise showed a higher degree of annoyance than those children from quieter areas. Evidence has been presented to suggest that children do not habituate to aircraft noise over time, and that an increase in noise can be correlated with a delay in reading comprehension compared to those children not exposed to high levels of aircraft noise.

5.3 It was suggested that language acquisition deficits may be related to the decrement in reading comprehension in children from noisy areas, but there is no agreement as to how these mechanisms are directly affected by noise.

5.4 It is largely recommended that future research needs to focus on longitudinal studies, to assess the long-term effects of chronic aircraft noise exposure on learning and cognitive ability in children. More detailed exploration of the mechanisms underlying the development of memory, attention and reading processes is needed, and how exposure to noise affects these. It would be useful to include measures of noise levels at home as well as at school. This would allow for the relative contribution of noise exposure at home to be assessed as well as at school, and allow for comparison between the two.

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Environmental Research and Consultancy Department

Aircraft noise and health effects: Recent findings

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Contents

Chapter 1

Introduction

1.1 The report aims to provide an update to the Environmental and Research Consultancy Department Report 0907 entitled Environmental Noise and Health Effects. Published in 2009, that report examined the evidence to date relating to transportation noise, in particular aircraft noise and the resulting impacts on various health endpoints. These included cardiovascular disease, night-time effects on sleep disturbance, children's cognition, psychological effects, performance and annoyance.

1.2 Aircraft noise and health effects is a rapidly growing area of research worldwide, and there have been many important findings published in recent years. Of particular importance has been the European Network of Noise and Health (ENNAH), which has connected researchers in the field throughout Europe to critically assess the current evidence base and identify gaps in the knowledge as well as suggesting directions for future research. The World Health Organisation (WHO) published their Burden of Disease from Environmental Noise report, which has enabled the calculation of healthy life years lost due to environmental noise which is very important for decisions on policy making. The European Environment Agency published their good practice guide on noise exposure and potential health effects which included important exposure-response relationships and thresholds for health endpoints and the Health and Safety Laboratory, through a Defra contract, produced their work on quantifying the links between environmental noise related hypertension and health effects.

1.3 In 2015 a review of aircraft noise and health effects by Charlotte Clark was published alongside the Airports Commission's final report on increasing airport capacity in the UK. The review was focused on the current state of knowledge concerning the effects of aircraft noise on a range of health outcomes, and the subsequent potential effects on exposed populations for three different expansion options. The review concluded that there is increasing evidence to support preventive measures such as insulation, policy, guidelines and limit values. Priorities for minimising the effects of aircraft noise should be focused on reducing annoyance, improving school environments for children and aiming to lower cardiovascular risk factors.

1.4 In addition to these key publications there have been many more studies into aviation noise and health effects since 2009. This report will review the main findings between 2009 and 2015 and will highlight areas that are considered important for future research.

1.5 The scope of this paper will focus around the cardiovascular impacts, sleep disturbance and children's learning with other areas such as performance and psychological effects being included. Although annoyance is often considered a health effect, for the purpose of this paper it will not be included as a single end point health effect, but of course it is appreciated that annoyance may be an important mediator in the relationship between aircraft noise, stress and various health endpoints such as cardiovascular disease. A dedicated CAP report on the current knowledge on aircraft noise and annoyance is planned.

Chapter 2

Cardiovascular effects

2.1 A Swedish study (Eriksson et al 2010) examined the cumulative gender-specific effects of aircraft noise on hypertension in a population of over 4000 adults residing close to Stockholm Arlanda airport. The study followed the participants over a period of 8-10 years and in addition to the main aim of investigating any potential differences between genders, the study also looked at the presence of sensitive sub-groups within the cohort. The study was part of a larger study on diabetes Type 2 risk factors and prevention measures, and therefore half of the sample in the aircraft noise study had a family history of diabetes. Baseline health measurements were taken at the beginning of the study, such as weight, waist and hip circumference and blood pressure. Participants also answered an extensive questionnaire on lifestyle factors and treatment for hypertension if there was any. After 8-10 years a follow-up questionnaire was administered with the same questions as in the baseline study, only with additional questions pertaining to aircraft noise and annoyance, noise sensitivity and diagnosis of hypertension.

2.2 Participants who were taking medication for hypertension at baseline were excluded from the aircraft noise study at follow up, along with those people displaying high blood pressure and/or those with missing data. During the study period the introduction of quieter aircraft resulted in a continuous decrease of the noise levels overall around the airport and interestingly a third runway was also built. This changed the flight paths which meant that most people experienced a decrease in noise levels, but as expected some areas experienced the opposite. Aircraft noise levels ranging from 50-65 dBA L_{den} were provided by Swedish Airports and Air Navigation Services, and were estimated with 1 dB(A) resolution using the Integrated Noise Model (INM). Exposure assessment was performed by Geographical Information Systems (GIS) and based on residential history during the period of the follow-up.

2.3 The results suggested that men and women exposed to 50 dBA L_{den} or above had a lower socioeconomic status and were more likely to work shifts than those exposed to below 50 dBA L_{den}. Alcohol consumption was lower for both sexes in the higher noise group also. Age and body mass index was associated with hypertension in males and females. Annoyance was strongly related to noise exposure, with 80% of people expressing annoyance when exposed to aircraft noise of 60 dBA L_{den} or above. Interestingly, males were more annoyed from 50 dBA L_{den} or above than females (36% and 29% respectively).

2.4 The hypertension results indicated that males were more likely to develop hypertension in areas exposed to 50 dB(A) L_{den} or above than females. For men the Relative Risk (RR) was 1.02 (95% CI 0.92-1.29) compared to women having a RR of 0.92 (95% CI 0.76-1.11). This was not a statistically significant difference among genders and as an overall sample there was no increased risk of hypertension following long-term aircraft noise exposure. However, when the cohort was restricted to those people not smoking at the time of the blood pressure measurements, a significant increase in risk per 5 dB was found in males RR 1.21 (1.05–1.39) but not in females RR 0.97(0.83–1.13). The authors explain that this may be due to nicotine having short-term effects on blood pressure and can therefore possibly skew the measurements. When both sexes were combined there was an increased risk for aircraft-noise related hypertension among those people that had reported annoyance to aircraft noise RR 1.42(1.11–1.82).

2.5 The authors suggest that it is possible that subjects with perceived noise annoyance represent a subgroup that is under greater risk of developing hypertension related to noise exposure. A possible explanation is that if noise-related hypertension is mediated through annoyance, this could contribute to explaining the observed gender difference in this study since men were more prone than women to report aircraft noise annoyance (36% and 29%, respectively). Observed annoyance levels were higher than expected, and this may be due to the increased awareness of aircraft noise with the opening of the third runway during the study period. An important point to consider when interpreting the difference in hypertension risk between the sexes is that on average women tend to develop hypertension when they are about ten years older than men, and this may be a contributing factor to the results observed in this study. It is also possible that the differences found between sexes may be attributable to confounding factors that are not accounted for. Finally, the sample used had a higher percentage of family history of diabetes (50%) compared to the standard proportion of 20-25% in the general population of corresponding age group which may predispose some of the population to a higher risk of cardiovascular disease.

2.6 Greiser et al (2011) published research concerning the risk increase of cardiovascular diseases and impact of aircraft noise in the Cologne-Bonn airport study. Previously, research had shown that there was an increase in the amount of cardiac medication prescribed with increasing aircraft noise exposure (2007). Aircraft, road and rail noise data were linked to hospital discharge diagnoses of just over one million people living in the study area. Confounders included age, environmental noise, prevalence of social welfare recipients of residential quarters and interaction of aircraft noise with age. The results showed that as age increased, the risk of cardiovascular disease decreased. Risk is more marked in females than males. For night-time aircraft noise of 50 dB L_{night} at aged 50, the odds ratio for cardiovascular disease in men was 1.22 and in women 1.54, for myocardial infarction it was 1.18 in men and 1.54 in women, for heart failure in men 1.52 and 1.59 in women, stroke in men 1.36 and for women 1.36 also. The lack of difference between males and females for heart failure risk and stroke contradicts the hypertension findings with respect to gender in the Swedish study, although this study uses the Lnight metric rather than L_{den}, which may be a factor.

2.7 Floud et al (2011) reported on medication use in relation to aircraft noise of populations surrounding six European airports, as part of the HYENA study. Differences were found between countries in terms of the effect of aircraft noise on antihypertensive use. For night-time aircraft noise a 10 dB increase was associated with an odds ratio of 1.34 (95% CI 1.14 to 1.57) for the UK and 1.19 (CI 1.02 to 1.38) for the Netherlands but no significant associations were found for other countries. There was also an association between aircraft noise and anxiolytic (anti-anxiety) medication, OR 1.28 (CI 1.04 to 1.57) for daytime and OR 1.27 (CI 1.01 to 1.59) for night-time. It should be noted that these confidence intervals are considerable in variation. This effect was found across countries. The authors concluded that although results suggested a possible effect of aircraft noise on the use of antihypertensive medication, the effect did not hold for all countries. The data was more consistent for anxiolytics in relation to aircraft noise across countries.

2.8 Harding et al (2011) on behalf of the Health and Safety Laboratory published a report on the quantification of noise related hypertension and the related health effects. The aims of the study were to identify the potential health outcomes associated with hypertension, to prioritise the health outcomes and quantify the links between noise and selected hypertension associated health outcomes. The second half of the report covered a methodology to allow a monetary value to be placed on the links between hypertension and health outcomes.

2.9 The base dose-response function for noise and hypertension used by Harding comes from Babisch and van Kamp (2009) who found an odds ratio for hypertension of 1.13 per 10 dBA increase in L_{den} in the range 45 to 70 dBA. Harding goes on to note that because the prevalence of hypertension in the population is greater than ten percent, that the odds ratio must be converted into relative risk in order to quantify the effect on the population.

2.10 Previously, the Interdepartmental Group on Cost Benefit analysis of noise IGCB(N) and WHO have considered that there is insufficient certainty from which to quantify the health outcomes from hypertension. However, Harding et al, after in depth review, found the following health outcomes from hypertension could be quantified.

2.11 The report concluded that there is substantial evidence for hypertension and blood pressure being an independent risk for cardiovascular disease (CVD).

Many studies investigating hypertension or blood pressure as an independent causal factor for CVD have used separate analyses for stroke and Ischaemic Heart Disease (IHD). It has been suggested that systolic blood pressure may be a better indicator of CVD risk than diastolic blood pressure.

2.12 The report discusses evidence of blood pressure being linked to all types of stroke, ischaemic (resulting from a clot) and haemorrhagic (rupturing of blood vessels within the brain). Hypertension is a known risk factor for strokes. There is strong evidence for a link between blood pressure and the incidence and mortality of IHD. IHD is due to the build up of plaque deposits on the artery walls and therefore leads to hardening of the arteries. When the plaque comes away from the walls, blockages can occur in the arteries which can cause a lack of oxygen (ischaemia) in the heart muscle. When the rupture of plaque on the coronary arteries occurs a clot can form, which can subsequently cause a rapid slowing or stop of blood flow and then the classic heart attack (myocardial infarction). There is evidence that lowering blood pressure can help prevent heart attacks.

2.13 The report discusses the evidence linking hypertension and dementia, or cognitive decline. The evidence is less strong than for cardiovascular disease, and is complicated by the ethical issues involved in studying long-term hypertension without treatment and also because by the time dementia manifests, hypertension can decrease as a result of weight loss or metabolic changes. There have also been findings that link cognitive decline with blood pressure in subjects aged 59-71 years.

2.14 The report also discussed the links between hypertension and end stage kidney disease, pregnancy, eye conditions and sexual function, but it was decided that based on the strength of the evidence and impact on the population that three health outcomes would be given priority in terms of quantification of links between noise and hypertension. These were Acute Myocardial Infarction (AMI), stroke and dementia. It should be noted that this study was designed to assess the risk of noise-related hypertension on the subsequent likelihood of hypertension resulting in the above health outcomes; it is not reporting that noise itself directly causes stroke and dementia.

2.15 Paunović et al (2011) published a critical review of studies into road and aircraft noise and children’s blood pressure. The aim of the review was to compare the methodologies used to assess blood pressure across the thirteen studies included. Of the seven studies on aircraft noise and children’s blood pressure, three were cross-sectional; four were longitudinal with a follow-up of between one and three years. The children were of similar age, between 8-12 years old, with weight and height measured and controlled for in most of the studies as well as ethnicity and in most cases, family history of hypertension. Noise exposure did vary across the studies, with some measurements being taken at schools, and some at residences. In terms of noise metrics, some studies used daytime levels; others used 24 hour noise levels, or monthly averaged exposure.

2.16 The measurement of blood pressure was fairly standard across the studies and used automatic measurement techniques, although there were discrepancies in terms of place, time and number of measurements taken and the degree of control for confounding factors. Despite these variations within the methodology, the authors conclude that there is a tendency toward positive association with noise exposure and an increase in children's blood pressure. It is recommended that more precise guidelines for measuring blood pressure in field studies are put in place. Some suggestions for such standardised protocols are summarised:

- Children's blood pressure should be measured at approximately the same time, either morning or afternoon.
- The place where measurement occurs should be familiar, well lit, quiet and comfortable.
- At least three measurements should be taken a few minutes apart, with the first reading being discarded.
- Measurements should be repeated the following day in the same setting if possible.
- Instructions should be given verbally and in written form.
- Measurements should be taken after breakfast, intense physical activity, coffee or energy drinks, and psychoactive substances such as nicotine.
- The child's emotions should be asked about and measurements avoided if there is expression of anxiety, fear anger or discomfort.
- Measurements should be avoided if the child has a headache or fever or is receiving any medical treatment at the time of the study.

2.17 Chang et al (2012) investigated the effects of environmental noise on 24 hour ambulatory vascular properties in adults. Vascular properties include resistance, which is the resistance to flow that is needed to be overcome in order for blood to be pushed through the circulatory system. Vascular compliance and distensibility (elasticity) is the ability of a blood vessel wall to expand and contract passively with an increase of pressure and cardiac relaxation and pulsation. Early changes in vascular properties can be pre-cursors to identified conditions such as increased blood pressure, ventricular hypertrophy (muscle wastage) and arteriosclerosis (thickening and hardening of the artery walls).

2.18 The aim of this study was to monitor personal environmental noise dose, in this case mainly traffic noise as participants lived at least 10km from an airport, using a personal noise dosimeter (50 dBA to 120 dBA), and changes in vascular properties using ambulatory non-invasive monitors worn on the wrist. Sixty six participants aged 18-32 years were recruited for the study from China Medical University in 2007. Participants answered a comprehensive screening questionnaire and refrained from smoking, caffeine, exercise, alcohol and listening to music for the duration of the study. The mean noise exposure for the daytime (0800-2300) was 61 dBA and for night-time (2300-0800) it was 48 dBA, with a 24 hour average of 56 dBA.

2.19 The results indicated that environmental noise exposure had temporary and sustained effects on vascular properties. There was an unexpected increase in arterial compliance during night-time, and a decrease in resistance during both daytime and night-time. Such changes were induced by present, 30 minute and 60 minute time-lagged noise exposures and contributed to the overall changes in vascular properties over a 24 hour period. The authors discuss possible theories as to why these changes occur, including as a reaction to stress-induced increased blood pressure, and interestingly as a possible response to noise-induced sleep disturbance. There was a lower arterial resistance at night-time compared with those measurements during the daytime among all subjects, which could explain the importance of noise disturbed sleep in cardiovascular diseases as sleep is an important modulator of cardiovascular function.

2.20 This is an important study as it is the first of its kind to provide evidence that environmental noise might affect structural changes in vascular properties that are related to hypertension. Although this study is not aircraft-noise specific it is possible that similar results may be observed as a response to aircraft noise and should be investigated in the future.

2.21 It is proposed that the physiological mechanism that is occurring may be that noise exposure causes the sympathetic and endocrine system to increase blood pressure. This then activates the muscular responses in arteries to allow for the surge of blood flow and t stabilise capillary pressure. It is these responses which produce the increased arterial compliance and decreased arterial resistance that subsequently prevent immediate damage within vessels.

2.22 In 2013 Babisch published a meta-analysis of noise and exposure-response curves between transportation noise and cardiovascular diseases. When considering epidemiological research approaches, Babisch stresses the importance of having a biological model for of how the noise exposure could affect health and the need for different research methods to be used to assess the impact rather than using the same methodology and therefore the same error, each time. He also discusses the possibility of a threshold of effect, which may arise due to biological reasons, or possibly due to imprecision in data and small sample sizes. There is a need for the magnitude of effect to have implications for public health, and only then if all of these factors are accounted for should a quantitative risk assessment including cost-benefit analysis should be employed to influence any decision-making processes.

2.23 For long-term noise exposure, Babisch updated his 2002 diagram representing the possible pathways that lead to health outcomes as a result of noise. In view of the experimental findings indicating that people do not physiologically habituate to noise exposure, even after being exposed for many years and even when they do not consciously report any disturbance during sleep for example, his updated model considers two pathways. The first is a non-conscious pathway via direct interactions of the acoustic nerve with the central nervous system, and the second is a conscious pathway via indirect physiological activation due to the emotional and cognitive reaction towards the noise. The theory is that both pathways result in changes in the autonomic and endocrine systems, resulting in unbalanced physiological and metabolic function, which may then result in cardiovascular disease in the long term. Babisch suggests that the indirect pathway may be dominant in people who are awake, and the direct pathway becomes dominant during sleep, and at much lower sound levels. This theory is represented in Figure 1.

2.24 Babisch produced a meta-analysis of results from road traffic and aircraft noise studies. Pooled effect estimates were derived from other meta-analyses on road noise and hypertension (24 studies, van Kempen and Babisch, 2012), road traffic and myocardial infarction (5 studies, Babisch, 2008), and aircraft noise and hypertension (5 studies, Babisch and van Kamp, 2009). Road traffic noise and stroke (Sørensen et al, 2011), and aircraft noise and myocardial infarction (Huss et al, 2011) each only contained one study, but were included in the analysis.

2.25 The exposure-response relationships are shown in Figure 2, and represent estimated relative risk with increasing sound level. The curves indicate that there is a higher risk of approximately 20-40% for those people where the weighted average outdoor level at the façade of their houses exceeds 65 dBA. Babisch suggests that if the difference between day and night noise levels is considered to be approximately 7-11 dBA, the findings can be converted to a night time noise level of 55 dBA. It should be acknowledged that there are wide variations between the onset of the exposure-response relationships, from L_{den} of 40 dBA to 60 dBA. It is of interest that that aircraft noise MI is such a higher risk than road traffic MI, yet the situation is reversed for hypertension, which is a known risk factor of MI. One critical factor in this research is that the very low aircraft noise exposure presented is an underestimate or was in the presence of other noise sources that were not accounted for.

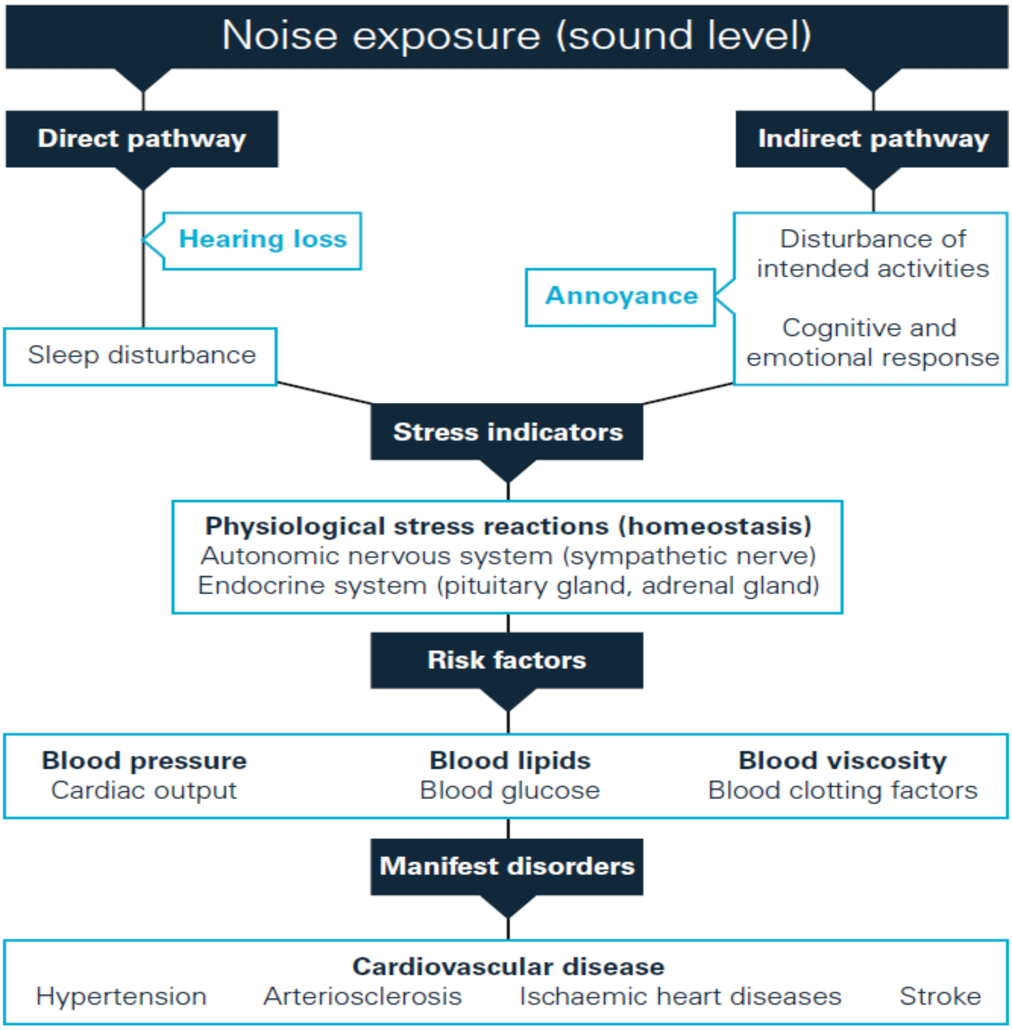

Figure 1: Noise reaction chart, updated version. Taken from Babisch, 2013.

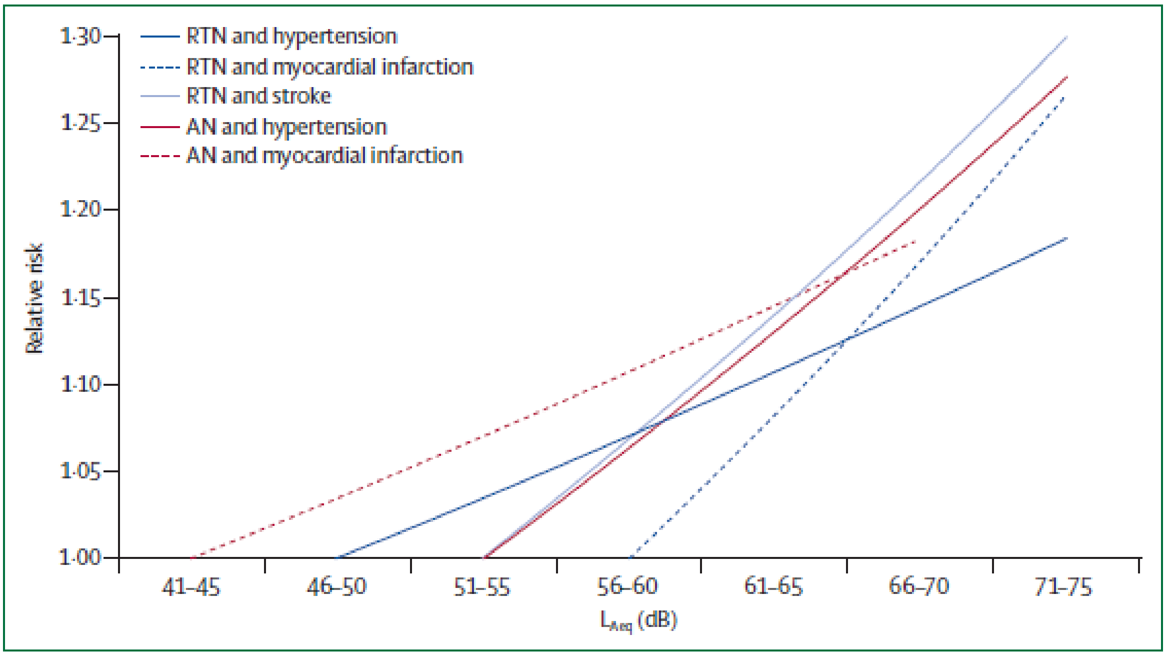

Figure 2: Exposure–response curves of road and aircraft noise and cardiovascular endpoints RTN and hypertension (24 studies, noise indicator LA_{eq} 16 h); RTN and myocardial infarction (five studies, noise indicator LA_{eq} 16 h); RTN and stroke (one study, noise indicator LDEN); AN and hypertension (five studies, noise indicator LDN); and AN and MI (one study, noise indicator LDN). RTN=road traffic noise. AN=aircraft noise.

2.26 Clearly, potential moderators and confounding variables need consideration in such research. These include location of rooms, windows being open or closed, length of residence, age, gender, and type of housing. Babisch suggests that future work should improve the noise assessment to consider secondary road networks and side streets, and quiet side dwellings should be included in the assessment. The issue of cumulative noise is important, i.e. it is critical to ensure that the dominant noise source is reflected in these types of studies. It is important that day-night differences should be investigated further, in relation to noise-induced sleep disturbance and development of cardiovascular diseases. Air pollution as a confounders or co-exposure also needs to be included in future work.

2.27 The findings from two UK studies focused around Heathrow airport were published in late 2013, and identified possible associations between aircraft-noise and health impacts on residents living in this vicinity.

2.28 The first was by Hansell et al (2013) from Imperial College, London which had the aim of investigating the association between aircraft noise and the risk of stroke, coronary heart disease and cardiovascular disease. The background to the research was that although there have been studies investigating cardiovascular effects of aircraft noise, the outcomes of those looking at stroke, coronary heart disease or cardiovascular disease are inconsistent. A possible reason for this may be due to a lack of statistical power because of the relatively small numbers of people exposed to high levels of aircraft noise.

2.29 This study examined comparisons between hospital admission rates for cardiovascular disease and mortality in neighbourhoods exposed to aircraft noise from Heathrow airport. Daytime (0700-2300) and night time (2300-0700) noise exposures were expressed as the average annual day LA_{eq}, 16 h and annual night LA_{eq}, 8 h respectively at a spatial resolution of 100 x 100 m, as estimated each year by the UK CAA and published by the Department for Transport. The study area included twelve London boroughs and nine districts to the west of London exposed to noise levels of at least 50dBA daytime (LA_{eq}, 16 h). For the twelve London boroughs data on air pollution in the form of particulate matter (PM10) at 20 x 20 m resolution, and road traffic noise at a spatial resolution of 10 x 10 m (LA_{eq}, 16 h) were also examined as potential confounding variables. Neighbourhoods were defined using the national census geographical units. The data on hospital admissions and deaths for 2001-2005 were obtained from the Office for National Statistics and Department of Health. The data for stroke, coronary heart disease and cardiovascular disease were then linked to postcode, geographic location and then noise exposure level. Confounders such as ethnicity, lung cancer (as a proxy for smoking) and deprivation were included.

2.30 Daytime aircraft noise and road noise was grouped into six categories from ≥51 to >63 dB in increments of 3 dB. For night time aircraft noise the increments were set at 5 dB intervals as less people were affected and categorised as ≤50, >50, and >55 dB. In order for a comparison between day and night time data to be made, daytime aircraft noise was also analysed using the same 5 dB groups. The study area covered 3.6 million people, only 2% living in the highest category of daytime or night time noise exposure.

2.31 The main findings on the hospital admissions with regard to stroke, coronary heart disease and cardiovascular disease are shown in Figure 3. With increased aircraft noise the risk of hospital admission also increased, with adjustment for ethnicity, deprivation and smoking included.

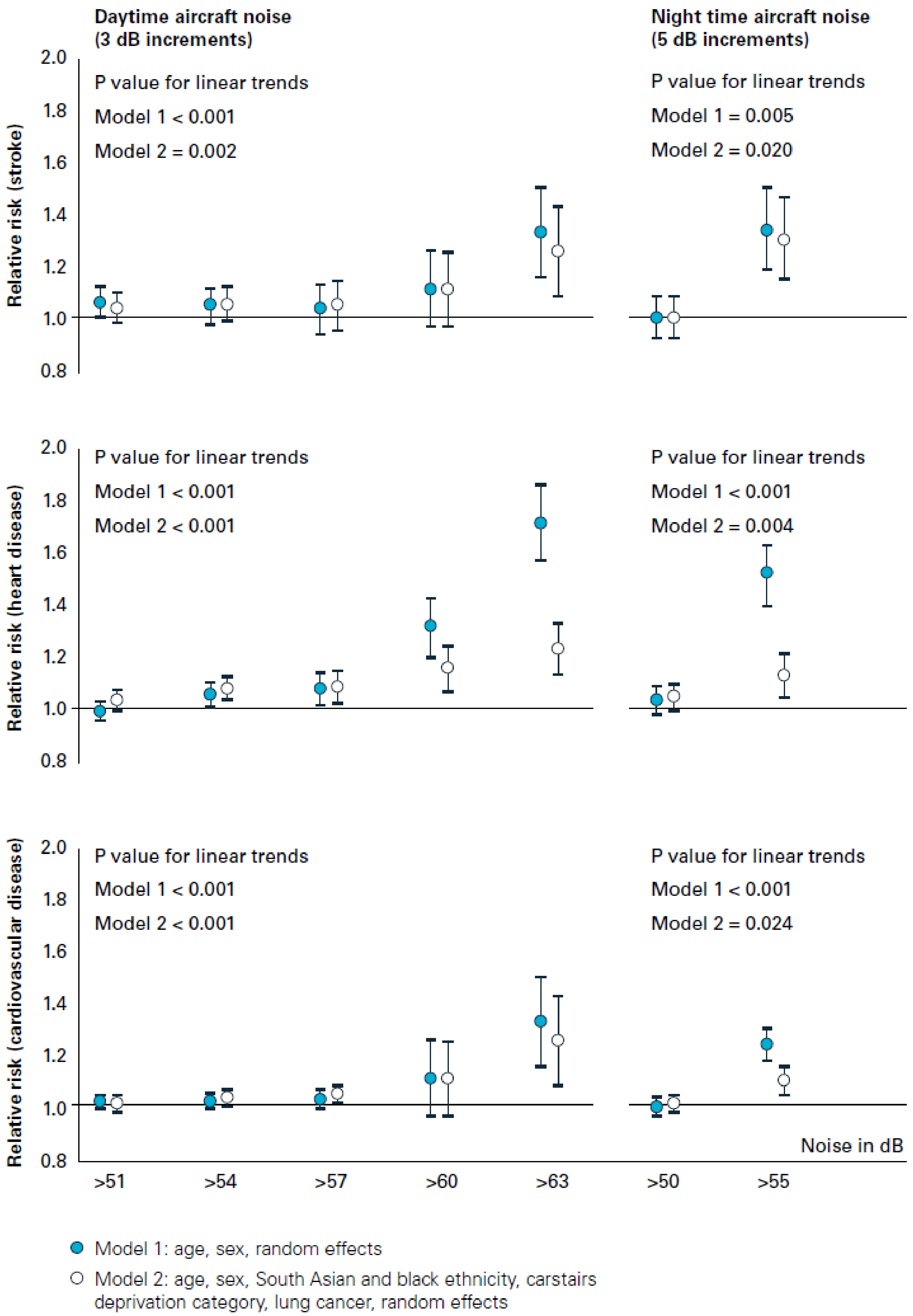

Figure 3: Relative risks for associations between hospital admissions for stroke coronary heart disease and cardiovascular disease between 2001 and 2005, and the annual weighted average daytime aircraft noise and night time aircraft noise in 2001 census output areas. Reproduced without permission from Hansell et al (2013).

2.32 The two sets of data illustrate the difference between the two types of adjustment for confounders. Model one represents adjustment for age, sex and random effects, and model two also includes ethnicity, deprivation and lung cancer. This separate analysis was chosen because the initial data highlighted that areas with a high proportion of South Asian and black ethnicity population were concentrated in the north eastern and eastern parts of the study area, which were also areas with higher deprivation and lung cancer risk.

2.33 Interestingly, adjustment for ethnicity, deprivation and lung cancer results in a much lesser degree of relative risk of hospital admissions particularly for coronary heart disease at noise exposure levels of more than 60 dB LA_{eq}, 16h. The same pattern is seen for cardiovascular disease, although to a lesser degree. It is important to consider the effect of ethnicity (in particular South Asian ethnicity, which is itself strongly associated with risk of coronary heart disease). The authors explained that when controlling for South Asian ethnicity in particular. It has a noticeable effect on these results, the effect due to noise exposure decreases quite dramatically. When comparing areas exposed to more than 63 dB LA_{eq}, 16 h to those exposed to 51 dB LA_{eq}, 16 h or less, the relative risk for hospital admissions due to stroke was 1.24 (1.08 to 1.43, 95% CI), for coronary heart disease was 1.21 (1.12 to 1.31, 95% CI) and for cardiovascular disease was 1.14 (1.08 to 1.20, 95% CI). The results for night time aircraft noise (>55 dB v ≤50 dB) were 1.29 (1.14 to 1.46, 95% CI), 1.12 (1.04 to 1.20, 95% CI) and 1.09 (1.04 to 1.14, 95% CI) respectively. When using the same categories for daytime and night time noise the results suggested higher relative risks for night time noise.

2.34 The corresponding results for relative risk of mortality were similar at the higher noise levels. In adjusted models for daytime aircraft noise (>63 dB v ≤51 dB) the relative risk for stroke mortality was 1.21 (95% confidence interval 0.98 to 1.49), for coronary heart disease was 1.15 (1.02 to 1.30), and for cardiovascular disease was 1.16 (1.04 to 1.29). The relative risks for night time aircraft noise (>55 dB v ≤50 dB) were 1.23 (1.02 to 1.26), 1.11 (0.99 to 1.24), and 1.14 (1.03 to 1.26) respectively. The results were unchanged with additional adjustment for PM_{10} and road traffic noise in the twelve boroughs of London. It was reported that the results obtained when using the same categories for daytime and night time aircraft noise indicated that the relative risks for mortality were higher for night time noise.

2.35 There are several issues to consider when interpreting the results from this study. Firstly, although road noise was included in the confounding variable analysis, rail noise was omitted which would have helped give a more representative group of noise confounders. Secondly, although the researchers have attempted to take into account the issue of confounding air pollution by including exposure to PM_{10}, they did not include exposure to Nitrogen Dioxides (NO_2), possibly because NO_2 is primarily linked with respiratory disease rather than cardiovascular disease. However, considering that NO2 concentrations exceed EU Air Quality limits at a number of locations within the study area - including both factors would have enabled any confounding effects of air pollution to be more fully understood.

2.36 In terms of the noise categories, the increments ceased at 63 dB and above. It is unclear why this number was chosen as the cut-off point and levels such as 66 dB and 69 dB and above were all grouped together in this category and not analysed separately, even though there should have been sufficient population numbers in order to perform discrete analyses. It is possible, however, that this choice was due to statistical sampling issues, whereby there were not enough hospital admissions or mortality cases to be grouped into separate noise categories.

2.37 As mentioned briefly earlier, the differences in effect size between the two models is marked, especially so for relative risk of hospital admissions for all three outcomes but especially for coronary heart disease at exposure levels of more than 60 dB and more than 63 dB.

2.38 When looking at mortality risk, as opposed to risk of hospital admission, the relative risk actually decreases to less than 1.0, for the noise exposure between 57 and 60 dB LA_{eq}, 16h, for stroke and cardiovascular disease in both models, although this effect is more pronounced for stroke. This suggests the possibility of a further confounding variable that has not been taken into account. The results also suggest a higher risk of mortality from coronary heart disease than cardiovascular disease. This is counter intuitive given that cardiovascular disease encompasses all the diseases of the heart and circulation, including coronary heart disease and stroke along with heart failure and congenital heart disease. It would be expected that the largest effect would be seen for the category of cardiovascular disease, and stroke and coronary heart disease would show smaller effects, as they are subsets of this.

2.39 For the night noise data, the upper limit cut-off is noise exposure of at least 55 dB, but it is not explained as to why this is the case. This appears to encompass a large range of noise levels in just one category, for example the risk factor could occur at much higher levels such as 69 dB, yet there is no distinction to allow for this possibility within the analysis and it would benefit from the refinement of noise categories.

2.40 It is acknowledged within the paper that it was not possible to have access to individual level information on confounders such as smoking, so results at area levels may not be applicable to individuals. It was not possible for the study to distinguish between short and long term effects of noise and length of residency in this study, which would merit further research. A potential source of bias may be the lack of information concerning the migration in and out of the study areas.

2.41 The differences between night time noise and day time noise could not be distinguished due to their high degree of correlation. The authors suggested that further research is needed to assess whether night time noise affecting sleep may be contributing to the observed results. In addition to possible causal relationships between aircraft noise and cardiovascular outcomes, it is important to consider the potential for confounding and ecological bias in this study. An important area for further research would be to determine the relative contribution of night time noise compared with daytime noise to the respective health endpoint.

2.42 An independent review of this study was commissioned by the Department of Environment, Food and Rural Affairs (Defra) and conducted by Stansfeld et al (2014). The review concluded that the study added to the evidence supporting the link between aircraft noise, coronary heart disease, stroke and cardiovascular mortality yet the associations were inconsistent across all measures. The reviewers suggested that this may be due to the relatively small association between aircraft noise and cardiovascular risk and the various confounding issues that are inevitable found in studies of this nature.

2.43 Due to the fact that it was not possible to control for confounders on an individual level, it is important to note that the effect size reported may be subject to a degree of error. The reviewers recommended that the effect magnitudes reported in the study should not be used in subsequent economic analyses.

2.44 The second study that included health effects around Heathrow was by Floud et al (2013), again from Imperial College, London. This European study was an extension to the Hypertension and Environmental Noise near Airports (HYENA) study, using self-reported data on heart disease and stroke between 2004 and 2006 from 4,712 people living near six European airports. This study examined road traffic noise and aircraft noise around London Heathrow, Amsterdam Schiphol, Stockholm Arlanda and Bromma, Milan Malpensa, Berlin Tegel and Athens Elephtherios Venizelos with the aim of investigating whether there is an association between exposure to aircraft noise or road traffic noise and heart disease and stroke.

2.45 In the HYENA study residents around the given airport were exposed to ranges of noise levels between less than 50 dBA to more than 60 dBA LA_{eq},16 h. As part of the health questionnaire participants were asked to declare if they had ever been diagnosed with angina, myocardial infarction (MI) or stroke whilst at their current address. This represented the ‘heart disease and stroke’ factor within this study. Aircraft noise was estimated for annual average day time (0700-2300) LA_{eq}, 16 h and night time (2300-0700) L_{night} and road traffic noise was estimated using the 24 hour metric LA_{eq}, 24 h. The lower limit cut-off levels were 35 dBA for daytime aircraft noise, 30 dBA for night time aircraft noise and 45 dBA for road traffic. The researchers appear to have chosen these very low noise exposures, because the information seemed to be available. Such low exposure data have not been validated and are typically associated with long-distance sound propagation with associated large uncertainty. Secondly, the aircraft noise values are from aircraft noise sources alone. However, overall ambient noise exposure levels in urban and suburban areas rarely drop below 40dBA, so the cut-off levels are likely to be below ambient noise exposure levels in much of the study areas.

2.46 In those study, as a possible confounder, nitrogen dioxide (NO_2) was estimated at participants' addresses using dispersion modelling in the UK, Netherlands and Sweden.

2.47 The results indicated that 5.9% of the study population responded with self-reported heart disease and stroke, with the UK having the highest proportion of 8%. Night time aircraft noise was associated with self-reported heart disease and stroke but this effect was no longer present when controlled for confounding variables such as age sex, body mass index, education and ethnicity. Importantly, when the length of residence was included in the analysis, there was a significant association for those people who had lived at their current address for 20 years or more (odds ratio 1.25, 95% confidence intervals of 1.03 to 1.51) per 10 dBA increase in noise exposure. However, in contrast to night time noise, daytime aircraft exposure had no significant association with heart disease and stroke before and after controlling for confounders.

2.48 For road noise there was an increase in proportion of self-reported heart disease and stroke that remained after controlling for confounding variables, and length of residence did not appear to display effect modification for this noise source. Weak correlations were found between aircraft noise and NO_2 levels, with moderate correlations found between road noise exposure and NO_2. For participants who had lived at the same address for 20 years or more the association between night time noise and heart disease and stroke was significant after adjustment for NO_2. When NO_2 levels were factored into the analysis for subsamples of 24 hour road noise exposure, the significant association was lost, which suggested that NO_2 is a confounding variable in this relationship.

2.49 There are important points to consider when interpreting the results from this study. Firstly, the data are self-reported, which may lend itself to over or under-reporting and therefore increasing bias within the sample. Secondly, the lack of statistical significance between daytime aircraft noise and heart disease and stroke is striking and should not be overlooked. It was in fact close to zero association. Clearly this may be due to participants being away at work during the day and therefore not being necessarily exposed to the noise dose that their house receives during the day.

2.50 The finding that night time aircraft noise was not significantly associated with self-reported heart disease and stroke after adjustment for confounders is of significance. However, given the association for those residents who had lived at the same address for 20 plus years, the results suggest that the relationship between aircraft noise exposure at night may be strengthened over time, and could be cumulative in nature.

2.51 This study found that associations between road noise and heart disease and stroke were confounded by air pollution, although the associations between aircraft noise and heart disease and stroke remained robust even after adjustment for NO_2. This is not unexpected, since road traffic is the predominant contributor to NO_2 pollution exposure. In addition the results suggested that for road traffic noise and heart disease and stroke, age may be a modifier as an association was found for those participants aged over 65 years. This probably needs to be investigated further however, in larger samples with increased power and the inclusion of air pollution as a co-exposure.

2.52 Although this study attempted to analyse air pollution as a confounding variable, the choice to use NO_2 alone does not fully represent the effects of air pollution, as particulate matter is also associated with transport emissions. Finally, although education level was controlled for in this study, socioeconomic status such as income or area-level deprivation was not taken into account and may also be a confounding factor.

2.53 This study provides a valuable insight into the associations between road traffic and aircraft noise and these particular health outcomes. Although the results suggest a possible long-term effect of night time aircraft noise (>20 years) on self-reported heart disease and stroke, the possibility of bias and further confounding issues should be considered carefully. In terms of road traffic noise and heart disease and stroke it is important to take into account the possible confounder of air pollution and age as an effect modifier before any firm conclusions can be drawn.

2.54 In addition to the two UK studies a US study was recently published by Correia et al (2013) from Boston School of Public Health and Harvard University, investigating aircraft noise exposure and hospital admission rates.

2.55 The aim was to investigate whether aircraft noise exposure is linked with hospital admissions due to cardiovascular disease in people of 65 years of age or older. The sample population was Medicare enrolees that lived close to 89 airports within the US. In total just over 6 million people aged 65 or more, enrolled in Medicare and residing in the 2,218 postcodes close to the 89 airports were studied. This sample size corresponds to approximately 15% of the entire US population of older people. The researchers used information from the Medicare insurance claims to analyse details such as when participants were admitted, length of stay, primary reason for admission, age, sex, ethnicity and postcode. In this study five specific types of cardiovascular disease were included: heart failure, heart rhythm disturbances, cerebrovascular events, ischemic heart disease and peripheral vascular disease. A total variable of cardiovascular disease admissions was defined as the sum of hospital emissions for all of these causes.

2.56 The noise data was obtained from noise exposure contours generated using the US Federal Aviation Administration's (FAA) Integrated Noise Model (INM), from 45 dB upwards. The metric used was the Day-Night Level (DNL) which adds a 10 dB penalty to night time noise (2200-0700). In addition the 90th centile was also included, which is the point at which 10% of the highest noise levels fall.

2.57 To address confounding variables such as socioeconomic status the researchers concluded that the percentage of Hispanic people and the median household income would be the two key variables included in the analysis. Air pollution in the form of particulate matter PM2.5 and ozone concentrations were included, as well as postcode level road density to control for road noise and road-related air pollution.

2.58 There were 2,218 postcodes (779 with both fine particulate matter and ozone data) and 6 027 363 Medicare enrollees residing within the 45 dB DNL contour of the 89 airports. The analysis was based on three regression models. Model 1 only accounted for individual variables such as age, sex and ethnicity, Model 2 also included postcode-level socioeconomic status and demographic variables, and Model 3 which in addition included pollution variables to Model 2. The results are shown in Figure 4.

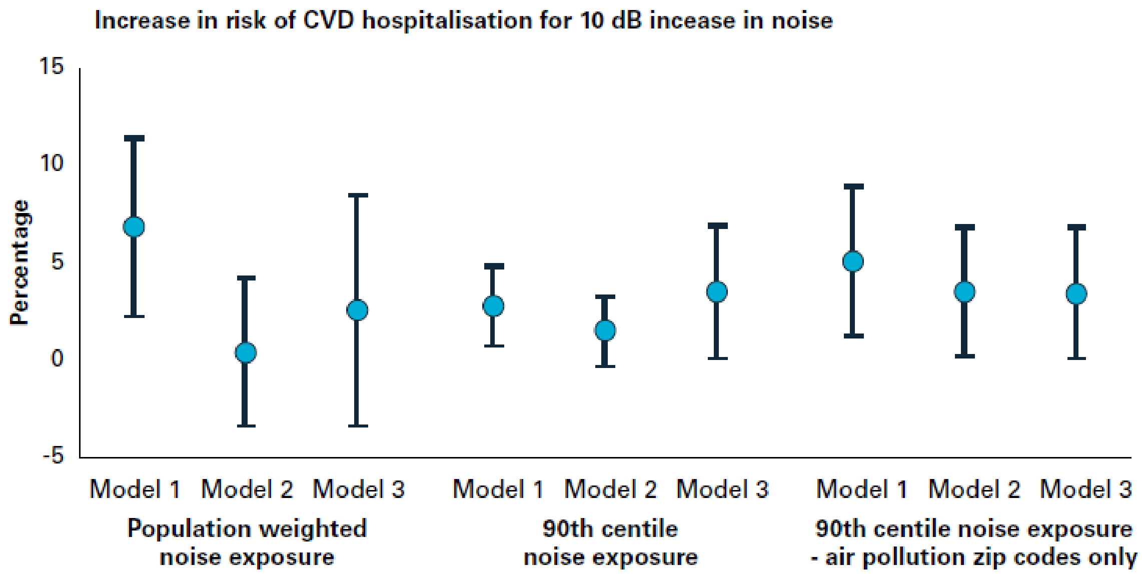

Figure 4: Overall estimates (averaged across 89 airports) of percentage increase in hospital admission rate for cardiovascular disease (CVD) associated with 10 dB (day-night sound level) increase in both exposure variables (population weighted noise exposure and 90th centile noise exposure) for each of the models. Model 1 controls for individual demographics (age, sex, and

race); model 2 additionally controls for postcode level socioeconomic status and demographics (% Hispanic and median household income); and model 3 adds to model 2 by also controlling for annual average fine particulate matter and ozone levels. Panel 3 shows models 1 to 3 fitted to only the 779 postcodes with both air pollution variables. Reproduced without permission from Correia et al (2013).

2.59 The results indicated that, for the 90th centile noise exposure category, when Model 1 was used which controlled for age, sex and ethnicity an increase of 10 dB was significantly associated with an increase of 2.9% in hospital admission rates. The significance decreased when controlling for additional socioeconomic status and demographic variables in Model 2 and was only marginally significant (1.6%). For model 3 which included air pollution, an increase in the 90th centile of noise of 10 dB was associated with an increase of 3.5% in the relative risk of cardiovascular disease hospitalisation. The third set of data points represent Models 1, 2 and 3 fitted only to those 779 postcodes where data for particulate matter and ozone were available and these also represented a statistically significant association with hospital admission for cardiovascular disease, suggesting that air pollution is not a confounding variable for these outcomes.

2.60 The points to consider when interpreting the findings are that the study employed a large sample size and therefore had substantial statistical power, compared to other cross sectional studies of this nature. It provides conflicting evidence to a previous study conducted around Schiphol airport, which found no evidence for increased hospital admissions due to aircraft noise exposure although it must be acknowledged that the Harvard study was able to assess individuals and account for a wider cross section of airports and populations and was also able to account for potential confounding effects of regional air pollution and near-road pollution and noise. The results also illustrated evidence for noise threshold for the observed increase in cardiovascular hospital admissions, with consistent statistically significant associations found only in the highest noise exposure group of 55 dB DNL and above.

2.61 An important limitation of the study is that the Medicare data used was developed for administrative purposes, and may be vulnerable to misclassification and discrepancies in management between areas. A further limitation is that the study did not control for smoking or diet, both of which are strong indicators for cardiovascular disease, due to the Medicare data not including this information. Socioeconomic status was calculated at an area level and therefore does not represent individuals in this data and from Census data from 2000, which is not necessarily representative of the most recent data from 2010.

2.62 The INM model has limitations also, due to the use of average annual noise level input which may mean that values could lack accuracy due to local acoustical variables not being accounted for.

2.63 This study did not differentiate between day time and night time noise exposure, in fact the noise variable, DNL, gives more weight to night time noise, so it was not possible to examine the role of night noise and potential sleep disturbance in hospital admissions, which may mediate the effects of aircraft noise exposure in relation to cardiovascular effects. Although the noise metric used incorporates a 10 dB penalty on night noise to reflect lower ambient noise levels at night, it would have been preferable to have separated out time of day effects in this sample and therefore no conclusions can be drawn from this data regarding night time aircraft noise exposure and cardiovascular hospital admissions in people aged 65 years and over.

2.64 Schmidt et al (2013) examined the effect of night time noise exposure on endothelial function and stress hormone release and the relationship with cardiovascular disease. The background to the study was the knowledge that in the case of aircraft noise, hypertension can be caused by the noise-induced stress release of hormones such as epi- and nor-epinephrine (adrenaline and nor-adrenaline) and/or the development of vascular (endothelial) dysfunction. Endothelial Dysfunction (ED) is considered one of the first steps towards atherosclerotic changes in the vasculature. As ED can be measured non-invasively, the aim of the study was to assess whether exposure to nocturnal aircraft noise may induce ED. A further measurement was the morning plasma measurement of adrenaline.

2.65 The study design used a blinded field study in 75 healthy volunteers (mean age 26 years), who were exposed at home, in random order, to one control pattern (no noise) and two different noise scenarios (30 or 60 aircraft noise events per night) with an average maximum noise level of 60 dBA L_{max} for one night each. Night time aircraft noise increased plasma epinephrine levels, worsened sleep quality, and decreased pulse transit time, a parameter of arterial stiffness, which varies inversely to arterial blood pressure. A dose dependent decrease in endothelial function after exposure to increasing levels of noise was also observed. Interestingly, a priming effect of aircraft noise on ED was observed, i.e. previous exposure to 30 noise events per night caused 60 noise events per night to have a larger effects on endothelial function. These data demonstrate that aircraft noise can affect endothelial function, and that rather than habituation, prior exposure to noise seems to amplify the negative effect of noise on endothelial function. Noise-induced ED may be in part due to the increased production in reactive oxygen species and may therefore be one mechanism contributing to the observed association of chronic noise exposure with cardiovascular disease.

2.66 The authors explain that the limitations of the study include no habituation nights, due to it being a field study and therefore this was not deemed necessary, and that the study sample was young, healthy adults, which is not representative of the whole population. However, the results from a healthy sample in this study indicate the requirement for further investigation into aircraft noise and ED in populations with pre-existing cardiovascular diseases.

2.67 A recently published review in the Lancet (Basner et al, 2014) looked at auditory and non-auditory aspects of noise with a focus on potential mitigation measures and noise prevention methods. The review summarises the knowledge on auditory effects of noise such as occupational noise-induced hearing loss, tinnitus and age-related hearing loss. The non-auditory part of the review discusses the effects of environmental noise exposure on annoyance, cardiovascular disease, cognitive impairment in children and sleep disturbance. The review summarises the WHO work, which estimates that in western European countries at least 1 million healthy life years (disability adjusted life years, or DALYs) are lost every year due to environmental noise, with most being attributed to sleep disturbance and annoyance.

2.68 In terms of cardiovascular disease the review discusses chronic and acute effects of environmental noise exposure, with chronic exposure contributing to hypertension, ischaemic heart disease and stroke and acute exposure being associated with arousals of the autonomic nervous system and endocrine system. The general stress model is suggested as a pathway for reactions such as increases in blood pressure and the release of stress hormones, with mechanisms such as stress reactions due to discomfort (indirect) and non-conscious physiological stress from interactions between the central auditory system and other regions of the central nervous system (direct). It is suggested that the direct pathway could be the more likely pathway during sleep.

2.69 With chronic noise exposure, metabolism and the cardiovascular system are affected, with increases in cardiovascular risk factors such as blood pressure, blood lipid levels, viscosity and blood glucose concentrations. The authors report that these changes increase the risk of hypertension, arteriosclerosis and are linked to myocardial infarction and stroke. It is suggested that due to the different acoustic characteristics for different noise sources, there is a need for different exposure-response curves for the different noise sources.

2.70 Meta-analyses were previously conducted for road and aircraft noise, and the relationship with cardiovascular disease such as ischaemic heart disease (including myocardial infarction) and hypertension. The studies suggested increases in risk of between 7% and 17% per 10 dB increase in equivalent noise level LA_{eq}. Their results have been adjusted for known risk factors such as age, sex, socioeconomic status, smoking, body-mass index, and others. The researchers identified sex and age as effect modifiers. The dose-response curves for the meta-analyses were shown in Figure 2.

2.71 Another recently published review was on the cardiovascular effects of environmental noise exposure (Münzel et al, 2014). Basner is also a co-author on this review and there are many similarities with the Lancet paper, although this review focuses solely on cardiovascular impacts of noise. The stress model is proposed as a mechanism for the pathway between environmental noise and cardiovascular responses, with the activation of two hormonal systems that help the body to cope with the stressor. These include the activation of sympathetic responses (flight or fight reactions) as well as the release of corticosteroids (defeat reaction). When people are exposed to very sudden or very loud noises e.g. low flying military aircraft noise, that can be perceived as aggressive or threatening, the fight or flight reaction is triggered. As a result, adrenaline and nor-adrenaline are released. Conversely, high-level noise events beyond the pain threshold and frightening sounds at lower levels increase plasma cortisol, the defeat reaction, aimed at mitigating the damages expected from the stressor. Such stress responses can result in changes in a number of physiological functions and in the homeostasis of several organs, including blood pressure, cardiac output, blood lipids, glucose, electrolytes and others.

2.72 The review explains the presence of nocturnal cortical arousals that result from noise as part of the Ascending Reticular Activating System, which is part of the body's arousal system. It receives input from several sensory systems, including the auditory system and relays this information to other parts, such as the cardio-respiratory network and through the Thalamus to the Cortex. It is explained that we recognise, evaluate, and react to environmental stimuli even when we are asleep and if such information is passed to the Cortex it can result in a cortical arousal which may disturb or fragment sleep. Interestingly, this is the reason that noise events do not result in an 'all or nothing' response, and not every event will lead to an awakening, but there can be a range of responses depending on the processing of the stimuli.

2.73 The differences in arousals between various types of environmental noise (road, rail and air) are discussed, with aircraft generally less likely to induce cortical or vegetative (e.g. heart rate and blood pressure) arousals compared to road or rail noise at the same Sound Pressure Level SPL. Despite this, aircraft noise is known to illicit higher annoyance responses than the other modes of transportation. The question of habituation is discussed, and generally speaking there is strong evidence for habituation to noise, for example, less arousals being observed in the field setting compared to the laboratory, and differences in responses between first study nights and subsequent nights. It is stressed; however, that habituation is not complete as people react to noise even after several years of exposure in the same environment. There is little known about the individual differences in the ability to habituate to noise, and arousals are still observed even after apparent habitation. Reactions such as increases in heart rate and blood pressure are known to habituate to a lesser degree than cortical arousals.

2.74 The review discusses the nocturnal effect of noise on the cardiovascular system and highlights the importance of the findings of Schmidt et al (2013) for supporting a link between nocturnal noise exposure and cardiovascular disease. In addition, it is explained that a sustained decrease in blood pressure during the night (dipping) is important for resetting the cardiovascular system and therefore for cardiovascular health. If environmental noise causes cortical arousals, sleep fragmentation and/or awakenings this may prevent the blood pressure dipping process and contribute to the risk for developing hypertension in those people exposed to night noise for prolonged periods. The authors suggest that there is sufficient evidence for nocturnal environmental noise effects on the cardiovascular system, autonomically in the instances of increases in heart rate and blood pressure, and directly, in terms of vascular function through endothelial dysfunction, that a biological rationale is provided for the increased risk of hypertension, myocardial infarction and stroke in those people with long-term exposure to sufficient noise levels.

2.75 Details concerning some of the limiting factors when researching noise and health effects are discussed, such as exposure-modifying factors such as length of residence, room location, sleeping with windows open or shut and presence of insulation. Co-exposures and multiple noise sources are also issues that need to be considered. The authors suggest that noise mitigation policies should consider the health implications of environmental noise exposure, and such strategies should be to improve noise reduction at source, active noise control, optimised traffic operations, planning consideration and improved sound insulation and limit values.

2.76 In late 2015 some of the results of the much-awaited NORAH (NOise-Related Annoyance, cognition and Health) study were published. This is a large-scale, longitudinal German study that commenced in April 2011 and continued until 2014 and included 43 researchers from 11 institutes. In order to get more insight into the effects of transportation noise, the state-owned Environment & Community Center (ECC) of the Forum Airport and Region (FFR) commissioned the authors to conduct a noise effects monitoring program at Frankfurt Airport before and after the opening of a fourth runway.

2.77 The study examined:

- Aircraft noise annoyance and health related quality of life (HQoL) before and after the opening of the fourth runway in comparison to annoyance at other airports;
- Comparison of HQoL and annoyance due to aircraft, railway and road traffic noise; effects of combined transportation noise exposure on annoyance and HQoL;
- Effects of transportation noise on hypertension and cardiovascular diseases and the causal structure of noise exposure, noise reactions, and health effects;

- Effects of changing nocturnal noise exposure at Frankfurt Airport on sleep;
- Noise effects on cognitive performance and quality of life (QoL) in children.

2.78 Three work packages are included in the study:

1. Annoyance and quality of life
2. Sleep and health
3. Children's cognition

2.79 The results from the sleep and children's learning studies will be reported in their respective chapters within this report. As part of the health work package, a blood pressure monitoring study was conducted from July 2012 -July 2013, and July 2013 -2014 with participants residing in the vicinity of Frankfurt airport and who were exposed to at least 40 dB during the day. Over 800 participants were trained on the use of blood pressure meters that were connected to mobile telephones in real time, and recorded their own blood pressure measurements each morning and evening for three weeks and then again one year later. In addition, participants completed a questionnaire with information on basic diseases, socioeconomic status, medication, lifestyle, body dimensions and self-reported noise sensitivity.

2.80 The researchers found no significant link between aircraft noise exposure and blood pressure, heart rate or pulse pressure. Similarly, no significant relationship between road or rail noise exposure and the named outcomes was found.

Chapter 3

Children's learning

3.1 Annoyance in children has rarely been studied; however one study by van Kempen et al, 2009, investigated annoyance reactions and exposure-response relationships to aircraft and road noise in both home and school environments. Data from the Road Traffic and Aircraft Noise Exposure and Children's cognition and Health (RANCH) study was used, with a secondary aim to compare children's annoyance reactions with those of their parents. Both parents and children's reactions were measured using self-administered questionnaires. The study was done on 2844 children, aged 9-11years from primary schools in areas surrounding London Heathrow, Amsterdam Schiphol and Madrid-Barajas airports. Aircraft noise exposure at home and school was significantly related to severe annoyance, in both cases where the noise exposure from aircraft was higher, the proportion of severely annoyed children was higher also. At school, the percentage of severely annoyed children was predicted to increase from 5% at 50 dBA L_{eq} 0700 - 2300 to about 12% at 60 dBA L_{eq} 0700-2300. At home these figures were 7% and 15% respectively. Road traffic noise at school was also significantly related to severe annoyance, with the percentage severely annoyed children predicted to increase from 4% at 50 dBA L_{eq} 0700-2300 to about 6% at 60 dBA L_{eq} 0700 - 2300. The association between annoyance and aircraft noise is stronger in children than road noise, probably due to the intensity, variability and unpredictability of aircraft noise in comparison to road noise. Children's annoyance reactions were found to be comparable to their parent's reactions, but with children having lower response rates of severe annoyance than their parents at higher noise levels of 55dB and above.

3.2 Van Kempen and van Kamp (2010) also studied the role of annoyance in the relationship between transportation noise and children's health and cognition. The aim of this study was to investigate whether annoyance may have been involved in the association between noise and cognitive functioning and health in the Road Traffic and Aircraft Noise exposure and Children's cognition and Health (RANCH) project. Children's health was measured by a symptom list and resting blood pressure as part of a physical examination. Cognitive testing was measured with various tests from the Neurobehavioral Evaluation System (NES). There were four main objectives of the study:

- To investigate the relationship between aircraft and road traffic and perceived health.
- To investigate whether annoyance is an intermediate step in the relationship between noise and cognitive functioning and health.

- To investigate whether annoyance confounds the association between noise and cognitive functioning and health.
- To investigate whether the relationship between noise and health and cognitive functioning differs between different annoyance groups.

3.3 The methodology used in the RANCH project has been described in previous reports (ERCD Report 0908) and in various research papers. In brief, the final sample contained 2,844 children aged 9–11 years attending 89 primary schools in areas around Heathrow Airport, UK, Schiphol Airport, Amsterdam and Madrid-Barajas Airport, Spain. Schools were selected according to the modelled air and road traffic noise exposures of the school area expressed as LA_{eq}, 0700-2300 h, and were matched on indicators of socio-economic status (SES) and ethnicity. Written consent was also obtained from the children. Blood pressure was taken in the UK and The Netherlands only, and the NES test batch was only administered in the Netherlands sample. All children were given a questionnaire for their mother or primary carer to complete at home concerning the child's health and behaviour, annoyance and possible confounding factors such as length of residence, window glazing, socioeconomic status etc.

3.4 The results indicated that UK schoolchildren were more annoyed due to aircraft noise at school than the Dutch and Spanish children (32%, 18% and 18% respectively). No direct associations were found between noise exposure at school and self-reported health symptoms: both air traffic and road traffic noise exposure at school were not related to a statistically significant increase in the number of symptoms. The relationship between noise and neurobehavioral functioning and health was not confounded by annoyance: the association with noise hardly changed after additional adjustment for annoyance. Associations were found between annoyance and self-reported health symptoms and the outcomes of several NES tests: children who were annoyed, reported more health symptoms compared to children who were not annoyed; children who were annoyed due to air traffic noise at school made significantly more faults at the Switch condition of the Switching Attention Test, and the span length of these children was also significantly shorter on the digital memory span test. Children who reported annoyance due to noise at school had a lower blood pressure compared to children that reported no annoyance. Finally, the relationship between noise and health and neurobehavioral functioning did not differ between different annoyance groups.

3.5 The authors explain that the findings suggest that noise may not only directly affect aspects of neurobehavioral functioning but that they also may be a result of levels of annoyance. In this study, this is illustrated by the findings that children who were annoyed due to air traffic noise at school made significantly more errors on the Switching Attention Test (SAT) compared to those children who were not annoyed due to aircraft noise at school. The results for the children in Amsterdam were also reported separately by van Kempen et al (2010) and were consistent with this finding on the SAT for the overall sample. This was also the case for the digital memory span test, with children that were annoyed due to aircraft noise at school having a shorter memory span length that those children not annoyed.

3.6 The blood pressure results were somewhat surprising in this study. Annoyance was not found to be a modifier of the association between noise exposure and blood pressure. Furthermore, annoyance was associated with decreases in blood pressure, and the observed differences between noise and blood pressure between annoyance groups were not significant. The decrease in blood pressure in the annoyed group does not fall into the expected outcomes of the general stress model where a subjective assessment of the stressor contributes to a stress outcome such as increased blood pressure.

3.7 There are several limitations to this study, such as potential misclassification of noise exposure with each child being assigned to school addresses which were linked to modelled equivalent aircraft and road traffic noise levels. Whilst, aircraft noise exposure is relatively uniform throughout the day at the airports studied, road traffic exposure may be subject to flow variations throughout the day. A further limitation is that this study only considered noise exposure at school, and clearly the children will spend a large part of their time at home. Part of this time will be spent sleeping, and it is possible that noise-induced sleep disturbance at home may be a contributing factor towards the performance decrements observed in the cognitive tests. However, the authors stress that aircraft noise levels were available at home for each of the three study locations, and road traffic at home only for the Dutch sample. In each of the three study locations, a high correlation was observed between aircraft noise levels at home and at school ($r = 0.83$-0.95). Due to the high correlation between the air traffic noise metrics, it was not possible to disentangle the effects of school and home noise exposure on perceived health in this study. Finally, there is a chance of recall bias in the self-reporting of symptoms on the health assessment aspect to this study.

3.8 The RANCH study was one of the largest investigations into the effects of environmental noise and children's cognition, and it is not surprising that the data has been used for much further analysis into this area. Stansfeld et al (2009) investigated the relationship between aircraft and road traffic noise exposure and children's mental health as part of a further analysis on data from the RANCH cohort. Stansfeld examined in more detail the sub-categories of the Strengths and Difficulties Questionnaire (SDQ) which is a well-established tool for analysis of psychological symptoms in children. Previous work has suggested there may be a link between aircraft noise and hyperactivity, although this was not found in another study investigating the same outcomes. As previously reported, the RANCH study looked at primary school children living around Heathrow, Schiphol and Madrid airports. 2844 pupils aged 9-10 years from 89 schools in total participated in the study. In each country primary schools were selected according to their noise exposure ranging from low exposure to high exposure for both road traffic and aircraft noise; 30-77 dBA L_{eq} for aircraft noise and 32-71 dBA L_{eq} for road traffic noise. All schools were matched according to socio-economic status and ethnicity within each country. There was no significant association between either aircraft or road traffic noise exposure and mental health measured by the total SDQ score. Aircraft noise was statistically significantly associated with higher scores on the hyperactivity subscale after full adjustment, and this effect differed significantly across countries and was strongest in the Netherlands. There was also a significant inverse relationship between road traffic noise and conduct behaviour, which was a surprising result. The results indicated that aircraft and road noise do not affect the children's overall mental health measured with this questionnaire; higher levels of aircraft noise were associated with higher scores on the hyperactivity subscale and higher levels of road traffic noise exposure were associated with lower scores on the conduct problems subscale. The authors stress that this finding needs further study and replication to be able to suggest a consistent link.

3.9 Stansfeld et al (2010) also examined the effect of night-time aircraft noise exposure on the cognitive performance of children. This analysis was also an extension of the RANCH study, and the Munich study in which 330 children were assessed on their cognitive performance in three waves, each a year apart, before and after the switch over of airports. Aircraft noise exposure and self-reported sleep quality measures were analysed across airports to examine whether changes in night-time noise exposure had any impact on reported sleep quality, and if this was then reflected in the pattern of change in cognitive performance. In the Munich study, analysis of sleep quality questions showed no evidence of interactions between airport, noise and measurement wave, which suggests that poor sleep quality does not mediate the association between noise exposure and cognition. In the RANCH study, there was no evidence to suggest that night noise had any additional effect to daytime noise exposure. The authors explain that this investigation utilised secondary data and therefore was not specifically designed to investigate night time aircraft noise exposure on cognitive performance in children, but the results from both studies suggest that night time aircraft nose exposure does not appear to add any further deleterious effect to the cognitive performance decrement induced by daytime noise alone. They recommend that future research should be focussed around the school, for the protection of children against the effects of aircraft noise exposure on performance.

3.10 Crombie et al (2011) reported on the effects of environmental noise exposure, early biological risk and mental health in nine to ten year old children. As in the paper described above, data was taken from the RANCH sample and mental health was assessed using the parental version of the Strengths and Difficulties Questionnaire (SDQ). The background to this study included research by Lercher et al, who found an interaction between early biological risk and ambient neighbourhood noise (predominantly road and rail noise at home) in children who were born prematurely or were of a low birth weight reported more mental health problems than those without this early biological risk. In their study ambient neighbourhood noise was estimated for the child's home address, however, a large part of a child's day is spent at school where they may also be exposed to environmental noise. It is therefore possible that the moderating effect of early biological risk found by Lercher et al may also exist for the relationship between noise exposure at school and mental health. The RANCH study had data available for aircraft and road traffic noise at school making it possible to look at the individual contributions of noise from these sources to the effect of early biological risk on mental health. The aim of this study was to investigate whether early biological risk moderates the relationship between road traffic noise or aircraft noise at school and mental health. Birth weight and gestation period were merged to create a dichotomous variable assessing 'early biological risk', in 1900 children from the RANCH cohort.

3.11 No interaction was found between either road traffic or aircraft noise at school and early biological risk for mental health outcomes. Nevertheless a main effect of early biological risk on mental health was found. The authors suggested that the findings surprisingly did not support those of Lercher et al, this in their view was due to the transient nature of aircraft noise compared to the more steady state sound levels of neighbourhood noise. Data from the RANCH study suggests that children with early biological risk; that is those born prematurely or with a low birth weight, have a greater chance of developing certain mental health outcomes but are not more vulnerable to the effects of aircraft and road traffic noise at school on mental health. The authors highlight the need to develop understanding of the pathways through which early biological risk might operate within future studies.

3.12 RANCH did not consider air pollution as a confounding factor. Clark et al (2012) therefore examined whether air pollution exposure at school (nitrogen dioxide) is associated with poorer child cognition and health, and whether adjustment for air pollution explains or moderates the previously observed associations of aircraft and road traffic noise at school on children's cognition in the 2001-2003 RANCH project. This secondary analysis of a sub-sample of the UK RANCH sample examines 719 9-10 year old children from 22 schools around London Heathrow airport, for whom air pollution data was available. This study had four aims. Firstly, to examine the correlations of aircraft noise exposure and road traffic noise exposure at school with air pollution measured at school for the UK RANCH sample. Secondly, to examine whether air pollution at school (NO2) was associated with poorer child cognition and health outcomes in the UK RANCH sample. The hypothesis was that air pollution would not be associated with impaired cognitive function and health. The third and fourth aims were to examine whether adjustment for air pollution at school would explain or moderate the previously observed associations of aircraft and road traffic noise exposure at school on children's health and cognition. Data was analysed using multi-level modelling. Air pollution exposure levels at school were moderate. They were not associated with a range of cognitive and health outcomes and did not account for, or moderate, associations between noise exposure and cognition. Aircraft noise exposure at school was significantly associated with poorer recognition memory and conceptual recall memory after adjustment for nitrogen dioxide. Aircraft noise exposure was also still associated with poorer reading comprehension and information recall memory after adjustment for nitrogen dioxide. Road traffic noise was not associated with cognition or health before or after adjustment for air pollution. Moderate levels of air pollution do not appear to confound associations of noise on cognition and health but further studies of areas that have higher air pollution levels are needed.

3.13 Xie and Kang (2012) published results of a study examining the environmental noise impact on academic achievements of students within inner and outer London areas. The aim of this study was to investigate the relationships between environmental noise levels of schools and a set of academic achievement factors and to determine the noise exposure of schools. Secondary schools in Greater London were studied. Four academic achievement indicators were considered, namely the average total point score per pupil of Key Stage 4, Contextual Value Added (CVA) score, overall and persistent absence. Five noise indicators were obtained after processing London noise map data, where road noise is the predominant noise source and the metric used is L_{den}. The results show that in the studied schools, the environmental noise levels have almost no significant relationships with the academic achievement indicators studied. As expected, the secondary schools in Inner London are noisier than those in Outer London, with an average difference of 2 dBA.

3.14 Seabi et al (2012) published research from South Africa on aircraft noise exposure, children's reading comprehension and the moderating effect of home language. Africa has eleven official languages, and although the majority of education is conducted in English followed by Afrikaans, there is a majority of the population (74%) that speak an indigenous (African) language as their first language. Therefore, for many pupils, English is their second and sometimes even their third language, which they may not be proficient in. Thus, English second language (ESL) learners may be at a double disadvantage, having to read and comprehend in their second language and simultaneously having to contend with background air traffic noise. The purpose of this study was to investigate the impact of chronic aircraft noise exposure and the moderating effect of home language on the learners' reading comprehension. The sample comprised 437 (52%) senior primary pupils exposed to high levels of aircraft noise (Experimental group) and 337 (48%) pupils residing in a quieter area (Control group). Of these, 151 pupils in the Experimental group spoke English as a first language (EFL) and 162 spoke English as a second language (ESL). In the Control group, the numbers were similarly divided. A univariate General Linear Model was used to investigate the effects of aircraft noise exposure and language on reading comprehension, while observing for the possible impact of intellectual ability, gender, and socioeconomic status on the results. A significant difference was observed between ESL and EFL pupils in favour of the latter ($F_{1,419} = 21.95$, $P =.000$). In addition a substantial and significant interaction effect was found between the experimental and control groups for the two language groups. For the EFL speakers there was a strong reduction in reading comprehension in the aircraft noise group. By contrast this difference was not significant for the ESL speakers. The findings are somewhat counterintuitive, the authors suggesting that factors such as learner motivation and access to learning resources could differ between EFL and ESL pupils and explain the findings, and may be worth future investigation alongside the moderating effect of home language. .

3.15 Clark et al (2013) examined the longitudinal effects of aircraft noise on children's health and cognition, via a follow-up study to RANCH six years after the original data was collected in 2001 - 2003, when the study sample of children were in secondary school. Longitudinal studies of environmental noise and children's learning are lacking, and there is a need for research in this area to examine if the associations between noise and cognition strengthen over time. Longitudinal studies can also help increase understanding of the causal pathways between noise and cognition and health, assist in the design of mitigation strategies, and to further inform policy. This study had three aims:

- To examine whether aircraft noise exposure at primary school showed longitudinal associations with reading comprehension, noise annoyance, and psychological health at follow-up six years later.
- To examine cross-sectional associations of aircraft noise exposure at secondary school on reading comprehension, noise annoyance, and psychological health, as few studies to date have examined noise associations on the health and cognition of children in this age group.
- To examine associations between cumulative aircraft noise exposure at primary and secondary school and reading comprehension, noise annoyance, and psychological health, to assess the combined effect of aircraft noise exposure across the child's schooling.

3.16 The authors hypothesised that those children attending each of the exposure categories (aircraft noise at primary school, aircraft noise at secondary school, and cumulative exposure) would exhibit poorer reading comprehension, higher noise annoyance and higher hyperactivity scores than children attending low aircraft noise exposure schools.

3.17 The follow-up study took place in 2008 and 27 secondary schools participated, compared to 29 primary schools that were part of the original RANCH study. For both studies, aircraft noise estimates were based on LA_{eq},16h outdoor contours that were provided by the UK CAA. These give the average noise exposure in dBA between 7 am and 11 pm for the school postcode. Baseline data were from July to September 1999; follow up data were from July to September 2007. Measurements of reading comprehension, psychological health, and noise annoyance were taken at the follow-up study. Sociodemographic factors that were assessed at baseline were also controlled for in the follow-up study. The response rate was 45%, with 461 subjects of a possible 1015 agreeing to take part. Baseline aircraft noise ranged from 34 dBA to 68 dBA with a mean exposure of 54 dBA. Follow-up aircraft noise exposure ranged from <50 dBA to 65.4 dBA with a mean exposure of 54 dBA. Overall, the majority of the children attended primary and secondary schools with similar noise exposure levels: 51.4% in the <51 dBA exposure category; 60.5% in the 51- 56.9 dBA exposure category; and 64.4% in the 57- 62.9 dBA category.

3.18 The main findings were that children exposed to aircraft noise at primary school reported significantly higher noise annoyance six years later at secondary school, even after taking noise annoyance at primary school into account. There were non-significant negative associations found between exposure to aircraft noise at primary school and poorer reading comprehension, but no association was observed between exposure to aircraft noise at primary school and poorer psychological health. Cumulative aircraft noise exposure at school and aircraft noise exposure at secondary school also showed significant associations with higher noise annoyance responses at secondary school, as well as non-significant negative associations with reading comprehension and no associations with psychological health.

3.19 The authors suggested that the non-significant negative association between aircraft noise exposure and reading comprehension may in part be due to the sample size, as the statistical coefficients were of similar size to those found in the primary school sample, yet were not significant in this sample, which suggests that large samples may be required for conclusively demonstrating noise effects on children's cognition. It is suggested that for future studies larger samples should be followed over time to assess whether associations of noise exposure in primary school on cognitive performance in secondary school can be found, as well as the further investigation of cumulative exposure.

3.20 No link was found with aircraft noise exposure in primary school, secondary school and cumulatively with psychological health and hyperactivity. The major limitation of this study was the degree of participant attrition between the baseline study and follow-up. Half of the sample was lost due to being untraceable after primary school, lack of school participation, or due to pupil absenteeism. This may have implications for underestimation of the observed effects for cognition and health later in the children's lives. Other limitations include the fact that the secondary schools may not be entirely representative of the population or of aircraft noise exposure as the sample was not selected on the basis of secondary school noise exposure. Further limitations include a lack of data about aircraft noise exposure at the child's home at follow-up; about internal classroom acoustics and about secondary school road traffic noise exposure or air pollution.

3.21 Seabi (2013) also conducted a prospective study into children's health and annoyance reactions to aircraft noise in South Africa. The aim of this study was to examine health and annoyance reactions to a change in chronic aircraft noise exposure and to investigate whether any effects would persist over time or be reversed following the relocation of Durban airport, and therefore a stop to noise exposure from aircraft.

3.22 Over 700 children with a mean age of 11.1 years participated in the first Wave of the study in 2009, 649 in Wave 2 (mean age 12.3 years) in 2010 and 174 in Wave 3 in 2011 (mean age 13.3). Wave 2 and 3 occurred following the relocation of the airport. The children in the present study came from five co-education public schools that were selected according to the noise exposure of the school area. Two highly exposed schools (HN group) were selected as the study population for the aircraft noise exposure area. The windows, walls, façade of the schools were not sound insulated. The low noise group comprised schools in locations not exposed to aircraft noise, but that matched the socio-demographic characteristics (such as age, language spoken at home, and social deprivation) of the high noise group. The baseline L_{eq} noise measurements for the High Noise groups at the noise exposed schools near the flight path (Wave 1) varied from 63.5 to 69.9 dBA L_{eq}. Maximum noise levels varied from 89.8 to 96.5 dBA L_{max}. Low noise groups for Wave 1 were between 54.4 and 55.3 dBA L_{eq} and 73.2–74.3 dBA L_{max}. Noise measurements during Waves 2 and 3 when aircraft were no longer at the previous location produced results at the formerly noise exposed schools of 55.2 dBA L_{eq} and maximum noise levels of 60.8 to 71.2 dBA L_{max}. Levels at the quieter schools were averages of 50.5 to 57.9 dBA L_{eq} and 60.6 to 70.5 dBA L_{max}.

3.23 The findings showed that children within the HN group continued to perceive a substantial amount of noise despite the relocation of the airport compared to those in the LN group at school. Although there was no significant difference in the perception of noise between the groups at Wave 1 at home, pupils in the LN group perceived greater noise levels than their counterparts at Wave 2 and Wave 3. The findings supported some of those found by Clark et al (2013) in the follow-up to RANCH, with the children who were exposed to chronic aircraft noise continued to experience significantly higher annoyance than their counterparts in all the waves at school, and only in Wave 1 and Wave 2 at home. Finally, despite the LN group exhibiting poor health scores at Wave 1 (a result which is unexpected and not understood), there was no significant difference between the groups on health outcomes in Wave 2 and Wave 3. The author suggests that chronic aircraft noise exposure may have a lasting effect on children's annoyance, but not on subjective health measurements. As with the RANCH follow-up study, there was a degree of attrition in this study, particularly for Wave 3 due to permission to follow-up children in Grade 8 (i.e. new schools) not being granted by some of the school teachers, as well as the bad weather during the assessment day, which resulted in many children not attending school. Noise exposure was only measured at schools and not at children's homes and finally the study only focuses on one source of noise. Suggestions for future longitudinal research includes measuring other sources such as road traffic noise, construction etc.

3.24 Although not aircraft noise-based or strictly cognitive, another recent paper described the results from the GINIplus and LISAplus German studies, looking at road traffic noise and children's behavioural problems and sleep disturbance (Tiesler et al, 2013). The rationale for this study was that most previous studies on transportation noise and children's health effects are on aircraft noise in schools, such as those described in this report. This study looked at road traffic noise at home in relation to behavioural problems and sleep disturbance.

3.25 Over 850 10-year old children from Munich participated. Noise levels at home as measured by L_{den} and L_{night} and behavioural problems were included in the study as assessed by the Strengths and Difficulties Questionnaire (SDQ). Briefly, the results suggested that noise exposure at the most exposed façade of the home was related to increased hyperactivity and noise at the least exposed façade of the building increased the chance for having borderline abnormal values on the emotional symptoms scale. The average value for the most exposed façade 52.4 dBA L_{den}, and the least exposed was 44.9 dBA L_{den}. At night this was 43.3 and 35.9 dBA L_{night} respectively. Night-time noise at the least exposed façade was associated with sleeping problems particularly in the ability to fall asleep in a sub-group of the study population for which this data was available. However, there was no significant association with the most exposed façade, suggesting confounding factors not addressed.

3.26 At the International Commission on Biological Effects of Noise (ICBEN) Congress in 2014, Charlotte Clark from Queen Mary University, London presented a study that was a further examination of the RANCH data and looked at teachers' reactions to environmental noise at school as a potential mechanism for noise effects on children's cognition.

3.27 Some of the mechanisms that have been suggested to account for how environmental noise may affect children's cognition include communication problems, teacher stress responses, learned helplessness, noise annoyance and frustration. The results of the RANCH study have been much reported elsewhere, (briefly that chronic noise exposure is associated with poorer reading comprehension and memory than non-noise exposed children) but this study focussed on the contribution of teachers' reactions to road and aircraft noise, and possible interaction with the children's learning outcomes.

3.28 Teachers in the RANCH study completed a questionnaire containing standardised measures of noise annoyance and perceived stress, as well as questions designed to assess perceptions of how they felt noise interfered with children's learning and performance. The five point ISO question was used to evaluate annoyance, and frequency of noise (road and aircraft) was assessed with a four point scale. The 10-item Perceived Stress Scale which assesses self-reported stress levels over the past month was also administered, along with questions relating to communication, student performance, quality of work etc.

3.29 270 teachers completed the questionnaires, and those exposed to aircraft noise at school were significantly more likely to report being moderately, very or extremely annoyed by aircraft noise at school than those teachers not exposed to aircraft noise at school. A similar association was found with traffic noise. Aircraft and road traffic noise were not associated with self-reported perceived stress, but teachers exposed to aircraft noise at school felt it significantly interfered with pupils' communication, concentration, performance, and quality of work. Similar associations were observed for road traffic noise. It is proposed that future analyses will explore these data as mechanisms for noise effects on children's learning within the RANCH project.

3.30 The European Network of Noise and Health (ENNAH) is discussed in detail in Chapter 6 of this report. As part of its work package on confounding and effect modifying factors, members were asked to draw causal diagrams for various effects and outcomes, to include potential confounders or moderating effects. Figure 5 shows the diagram produced for the causal pathways between aircraft noise and road noise and children's learning outcomes.

3.31 Although such diagrams are a useful tool for stimulating discussion and broad thinking about potential confounders and causal pathways, due to conflicting evidence it is not possible to draw conclusions. The group therefore suggest that the study of interactions should be given a high priority in future research into environmental noise and health. As part of this work package the RANCH study data was analysed further. Interestingly, air pollution was not found to be related to children's health and cognition in this study, and effects persisted even after air pollution was controlled for. In the HYENA study, which was also analysed further by this group, the aircraft noise $L_{eq16hour}$ distribution by country showed higher exposures for the UK and the Netherlands than for Sweden, whereas the road traffic noise $L_{eq24hour}$ distribution was similar for the three countries. For NO_2, there are quite considerable differences between the countries with no overlap between the UK and Swedish data despite the similarities in road traffic noise distribution.

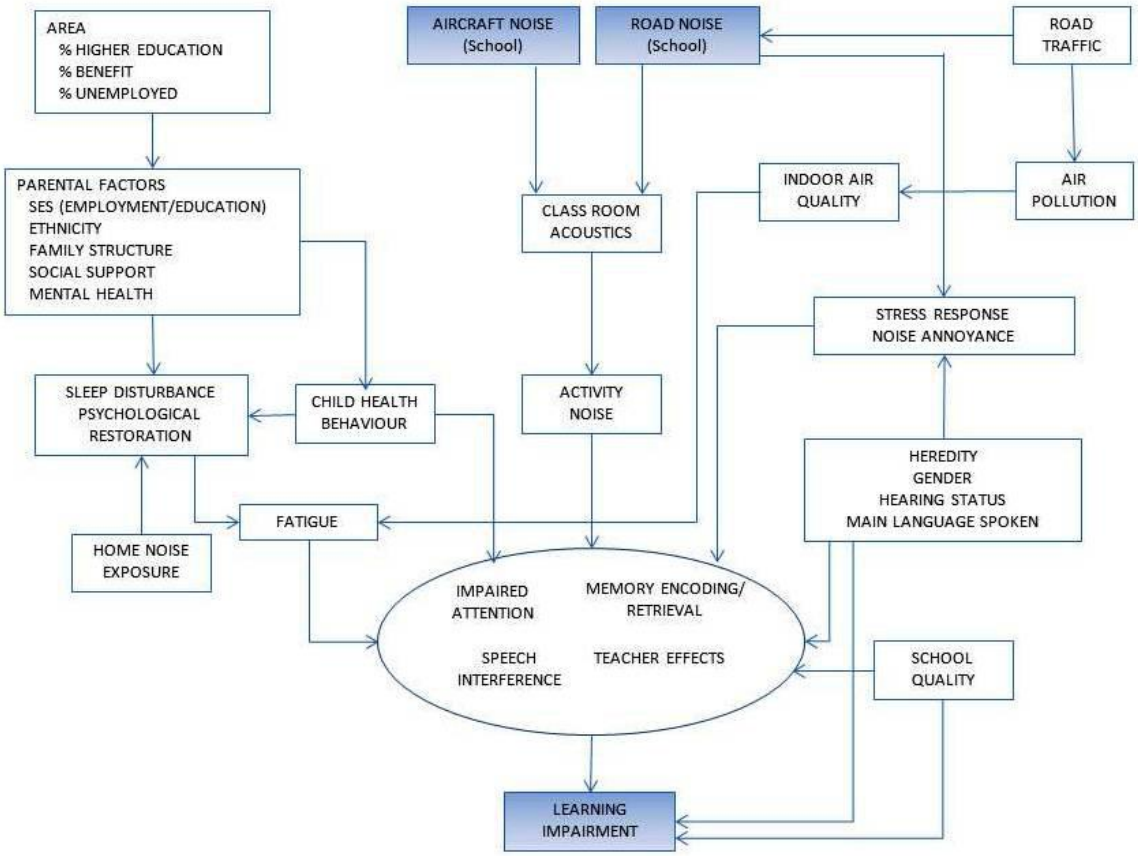

Figure 5: Association between road traffic and aircraft noise and learning impairment (taken from the ENNAH final report, 2013).

3.32 In late 2015 the initial results of the NORAH study were published. A description of the study can be found in Chapter 1 of this report. One of the work packages in this study investigated the effect of aircraft noise on children's cognition. Over 1200 primary school children were recruited from outside the 40 dBA L_{eq} envelope of daytime aircraft noise, and the schools were banded according to their noise exposure (40 – 45 dBA; 45 – 50 dBA; 50 – 55 dBA and > 55 dBA), with 7 or 8 schools in each category.

3.33 Reading ability, long-term memory, non-verbal abilities, attention, speech perception, verbal short-term memory and phonological awareness were assessed. Variables known to affect reading acquisition such as teachers' methods of reading instruction, children's SES and language spoken at home were assessed via teacher and parent questionnaires. In addition to cognitive tasks, children's quality of life was assessed via standardised interviews of the children and parent questionnaires.

3.34 The findings of the NORAH study for children's learning reflected a small but significant decrease in reading performance equivalent to a one month reading delay, with an increase in aircraft noise levels of 10 dB LA_{eq}. One theory behind the way in which aircraft noise may impact on children's reading ability is that the noise interferes with pre-cursor skills, which children develop prior to school age. Such skills allow for the identification of sounds and good comprehension and listening skills. The researchers investigated these and found no significant effects of aircraft noise in relation to memory and phonological processing. To put the magnitude of the observed effect into perspective, the researchers stated that children who read at home are four months ahead in terms of reading texts compared to those who do not own their own books. This suggests that perhaps greater emphasis should be put on parents helping and encouraging children to read at home for increased progress with reading ability, than on the relatively small negative effect observed in relation to aircraft noise.

3.35 In terms of QoL, the authors reported that in general, all of the children studies exhibited a high level of QoL and they felt very well, healthy and enjoyed going to school. However, children exposed to higher aircraft noise levels reported symptoms such as headaches and stomach aches more often than those children who live in quieter areas. Parents in higher noise areas also reported that their child was taking prescribed medication or had been diagnosed with a speech or language disorder.

Chapter 4
Sleep disturbance and night noise effects

4.1 In January 2013, the CAA ERCD Report 1208 was published, entitled ‘Aircraft Noise, Sleep Disturbance and Health Effects: A Review’. This report provided an overview of the main findings within environmental noise at night and health research from the 1970s to 2013, and included the effects of sleep disturbance due to aircraft noise. The cost-benefit analysis of night flights was also discussed in terms of previous methodology and proposals for future evaluation of the aircraft movements at night were suggested.

4.2 This report covered the main effects of nocturnal environmental noise, such as cardiovascular disease, sleep disturbance and next day effects, and the impacts on children. It is not the intention to replicate ERCD 1208 in this report, as it already provides a thorough description of night noise effects and economic analysis methodology as it stands. Instead, this section will focus on the research that has been published since that report, from 2012 to the present day.

4.3 Hume et al (2012) published a review of the effects of environmental noise on sleep. This review highlighted the current state of knowledge and suggestions for future research directions. The current knowledge includes evidence for autonomic responses to low noise levels that do not result in awakenings, sleep stage changes, movement and brief wakefulness which can be associated with limb and body movement, the association between night noise and cardiovascular disease and that autonomic arousals habituate less in response to noise than cortical arousals. The authors suggest that the evidence does lack a causal pathway that directly links noise, sleep disturbance and cardiovascular disease. This could be addressed by a large scale longitudinal study that would measure noise-induced sleep disturbance and follows participants over several years but this would clearly be expensive and the results would take a long time to achieve.

4.4 An important consideration in studying noise-induced sleep disturbance is the presence of naturally occurring awakenings. We all experience spontaneous awakenings during the course of a normal night’s sleep and we usually do not remember them, nor do they cause deleterious effects on alertness or next day performance. The challenge for noise and sleep researchers is to differentiate the naturally occurring spontaneous awakenings from those induced by noise. Previous research in 2011 on single and combined road, rail and aircraft noise exposures found that most (>90%) of the noise induced awakenings merely replaced awakenings that would have occurred spontaneously, and helped to preserve sleep continuity and structure despite the noise. The authors state that this suggests that within limits there is some homeostatic mechanism for internal monitoring and control of waking arousals (or maintaining sleep) that are allowed during each night's sleep.

4.5 The review describes the requirement for continued research into the area of transportation noise and sleep disturbance and other health effects and cites the predictions from the International Civil Aviation Organisation (ICAO) Environment Report (2010) which reports that in 2006 the global population exposed to aircraft noise with 55 LDN or above was approximately 21 million people. This is expected to increase at a rate of 0.7 to 1.6% per year, while passenger traffic is expected to grow at an average rate of 4.8% per year until the year 2036.

4.6 The WHO Night Noise Guidelines (NNG) (2009) and the WHO Burden of Disease Report (2011) are briefly referred to in the review, both of which are described in ERCD Report 1208. To recap, the NNG summarise the relationship between night noise and health effects into four ranges of continuous outside sound level at night (L_{night}):

- <30 dB - Although individual sensitivities and circumstances differ, it appears that up to this level no substantial biological effects are observed.
- 30-40 dB - A number of effects on sleep are observed from this range: Body movements, awakening, self-reported sleep disturbance, and arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (e.g., children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest.
- 40-55 dB - Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
- >55 dB - The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep disturbed. There is evidence that the risk of cardiovascular disease increases

4.7 WHO's view is that above 55 dB L_{night} noise is a significant concern to public health. As a result it has set an interim target of 55 dB $L_{night,outside}$. For the longer term it recommends that night noise exposure should be reduced below 40 dB $L_{night,outside}$. It is explained that the interim target is recommended in the situations where the achievement of the NNG is not feasible in the short-term for various reasons. With present technology, achievement of the 40 dB L_{night} target would require almost complete closure of all transport systems, including roads, railways and airports. The interim target is not a health-based limit value by itself and vulnerable groups cannot be protected at this level.

4.8 The WHO Burden of Disease report suggests that sleep disturbance, due mainly to road traffic noise, constitutes the heaviest burden followed by annoyance which account for 903 000 and 587 000 DALYs, respectively. The other factors associated with environmental noise are ischemic heart disease (61 000 DALYs), cognitive impairment in children (45 000 DALYs) and tinnitus (22 000 DALYs). The report concludes with the estimate that at least one million healthy life years are lost every year from traffic related noise in Western Europe.

4.9 Perron et al (2012) also conducted a review of the effect of aircraft noise on sleep disturbance. This review included many of the papers discussed in ERCD 1208 and only included research that was published until 2010. All moderate-to high-quality studies of the twelve reviewed showed a link between aircraft noise events and sleep disturbances such as awakenings, decreased slow wave sleep time or the use of sleep medication.

4.10 The authors identified several gaps in current knowledge that need to be addressed. There is a void of studies examining the effects of aircraft noise on the sleep of older people and those with chronic illnesses and pre-existing sleep disorders. Parameters such as total sleep time, awakenings, Slow Wave Sleep (SWS) time, and Rapid Eye Movement (REM) stage sleep time should all be investigated in these groups. There is a need to further understand the role of annoyance in sleep disturbance and how this is characterised. It is also suggested that the influence of background noise should be examined on aircraft noise effects.

4.11 Fidell et al (2013) from the USA published their research on aircraft noise-induced awakenings and types of sound exposure. The paper discusses the problems surrounding the use of absolute indoor sound exposure levels (SEL) to predict aircraft noise-induced awakenings. The authors refer to the American National Standards Institute publication (ANSI, 2008) which identifies two methods of measuring noise-induced awakening. The first method predicts the probability that an individual noise event will awaken a person as a result of its SEL alone. The second method predicts the probability that an entire distribution of aircraft noise intrusions over the course of a night will awaken a person at least once (or multiple times). These methods are examined by Fidell et al and it is explained that the statistical reasoning on which the second method is based relies heavily on the analysis of the first method and a strong assumption of complete independence of awakenings from one another throughout the night.

4.12 The authors argue that these methods do not take into consideration the role that habituation may play in the likelihood of aircraft noise-induced awakenings. They present evidence for different awakening rates at similar noise exposure levels at different airports, described as adaptation level theory. This hypothesis is that noise events that deviate from community expectations following habituation to familiar night-time noise environments are more likely to awaken residents than those which conform to their expectations about night time noise. Further evidence for the role of habituation is that the probability of awakening seems to be more closely tied to the standard deviate of a noise event's SEL at a particular airport rather than the absolute value. The odds ratios of awakening due to individual noise events do not seem to be closely related to absolute sound levels. Finally, the probability of awakening due to road noise or aircraft noise seems to be source-specific.

4.13 The authors conclude that the current state of knowledge for predicting aircraft noise- induced awakenings using absolute indoor SELs falls somewhat short and there is uncertainty surrounding the methods. Of particular importance is the need for habituation to be factored in to methods recommended for the prediction of aircraft noise-induced awakenings.

4.14 Boes et al (2013) reported their results on aircraft noise, health and residential sorting. The authors explain the limitations of using cross-sectional experimental data and the reason why evidence from such studies cannot be given a casual interpretation. This is because individuals are not randomly exposed to noise and neighbourhoods differ in other characteristics other than noise, such as quality of the area. In addition, people may self-select into areas based on their preferences for quietness, pre-existing health conditions, and their ability to afford to live in a quiet neighbourhood. This inevitably leads noise-sensitive people to live in quiet areas, and noise-insensitive and resistant people to live in noisier and often more affordable areas. Boes et al use fixed effects models, (statistical models that represent the observed quantities in terms of explanatory variables that are treated as if the quantities were non-random), to control for time-constant confounders, including both unobserved individual heterogeneity and spatial sorting into different neighbourhoods related to health.

4.15 The study took advantage of two changes in operations at Zurich airport, the first being the closure of the east/west runway for two months in summer 2000 due to a new terminal building being constructed. During this period, aircraft used the north/south runway instead of the east/west one. The second large-scale change was in 2003 when the German government prohibited landings over their territory in the early morning and in the late evening as a protective measure against noise pollution. After a temporary redistribution of incoming flights to the east, the Swiss Federal Office of Civil Aviation changed the flight regulations to allow for landings from the south, which had been previously prohibited.

4.16 After this change which started in October 2003, early morning aircraft were redirected to land from the south and late evening aircraft from the east. Self-reported health data was used from the Swiss Household Panel (SHP) which is collected annually from 5,000 members of the Swiss population. The researchers looked at subjective health outcomes that were likely to be impacted by aircraft noise such as sleep quality, headaches, 'weakness/weariness', and measures of general health such as the number of doctor consultations and days affected by health issues. Each person in the SHP was linked to detailed continuous and longitudinal aircraft data based on their address.

4.17 Interestingly, the researchers suggest that cross-sectional study designs and analysis of aircraft noise and health effects probably underestimate the effects. It is explained that in such cross-sectional studies the association between aircraft noise and health is often insignificant or very small, but once individual fixed effects are included, aircraft noise is found to significantly increase sleeping problems and headaches. A possible reason for this difference is that noise sensitive people will self-select to live in quieter areas and therefore the population there is negatively linked with respect to pre-existing health inputs. It is suggested that those studies that do not control for such type of sorting will consequently underestimate the causal effect of noise on health. Individual fixed effects used in this study control for noise sensitivity, which is a stable trait that is independent of observed noise levels.

4.18 A further explanation is the presence of habituation to noise. If this process occurs slowly, the underestimation of noise effects due to habituation will be smaller in fixed effects models than in cross-sectional models. In addition, avoidance behaviour could also influence the results, such as closing windows at night, and soundproofing. The authors suggest that this methodology using fixed effects is a powerful way of indentifying causal effects in epidemiological field studies such as those employed in noise and health research.

4.19 In 2013 a Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) report in collaboration with FAA, NASA and Transport Canada, authored by McGuire and Davies was published on the various ways to model aircraft noise-induced sleep disturbance. The report discusses the use of previously developed models, which generally predict the percentage of the population that is awakened. Other models such as Markov state and nonlinear models have been used to predict individual sleep structure throughout the night.

4.20 The report explains the limitations of such models, for example the Markov model only allows for whether an aircraft noise event occurred and does not take account of the noise level or other sound factors which may influence the amount of disturbance. The nonlinear dynamic models were developed to describe normal sleep regulation and do not have a noise effects component. In addition, the nonlinear dynamic models have slow dynamics which make it difficult to predict short duration awakenings which occur both spontaneously and as a result of night-time noise exposure.

4.21 The report discusses the ways in which the models can be improved to more accurately predict the effects of aircraft noise on sleep and then comparisons are made between the results when tested on data from US flight operations data. The thesis is a highly detailed and complex report, and explores many modifications of existing sleep models. In brief, a nonlinear dynamic model was developed by the authors that may be a possible tool for predicting sleep disturbance in communities if further refinements are made to it. The model was based on the 1999 UK sleep study data set, and it is explained that it also needs to be tested on other datasets for further validation.

4.22 One of the advantages of this type of model is that model coefficients can be related to specific physiological processes and the parameters of the nonlinear model can be estimated using data for each subject night. The authors explain that this may enable sleep disturbance to be predicted for a variety of subgroups within populations, such as the elderly, children and vulnerable groups who may have conditions that affect their sleep by estimating and using a different set of model parameters for each group.

4.23 Janssen et al (2014) examined the effect of number of aircraft noise events on sleep quality. The rationale for this study was that although WHO recommends the use of L_{night} as the primary indicator for sleep disturbance, there is some evidence to suggest that the number, characteristics and distribution of individual noise events throughout the night can impact sleep disturbance. The authors explain that the WHO NNG and the European Noise Directive (END) allow the use of of both the maximum sound pressure level (LA_{max}) and sound exposure level (SEL) in addition to L_{night} to predict sleep quality.

4.24 The aim of the study was to investigate whether L_{night} sufficiently represents the number of aircraft noise events that contribute towards prediction of sleep disturbance by motility, and the association between sleep quality and number of events. The second aim was to investigate whether the number of events at a given L_{night} has an additional predictive value. In addition, it was explored whether the total number of events should be taken into account for the production of sleep quality, or only the number of events exceeding a certain sound pressure level.

4.25 Data collection occurred around Schiphol airport between 1991 and 2001 from 419 residents at varying distances from the airport. The study lasted eleven days and participants were requested to complete morning and evening diaries, reaction time tests, sleepiness scales and wearing an actiwatch for the duration of the study. They were exposed to normal aircraft noise levels at home, all of which were within 20km of the airport, and selected on the basis of their L_{night} noise levels. Sleep quality was determined by self reported sleepiness and actigraphy, which also measured motility.

4.26 The results indicated that additional information on the overall number of events does not improve the prediction of sleep quality. The number of events of higher noise levels (> 60 dBA L_{max}) was associated with an increase in motility, which suggests a decrease in sleep quality. There was no effect of number on self-reported sleep quality. The authors suggested that the number of events is more or less adequately represented by L_{night} and only the number of high noise level events may possibly have additional effects on sleep quality as measured by motility. It is proposed that in addition to L_{night}, the number of events with a relatively high LA_{max} could be used as a basis for protection against noise-induced sleep disturbance.

4.27 The sleep study results from the NORAH study were published in 2015. This study aimed to examine any changes in sleep quality and disturbance as a result of changes to the nocturnal volume of air traffic at Frankfurt Airport. In October 2011 night flying restrictions for scheduled flights were imposed from 2300 to 0500, with only delayed arrivals or departures being allowed as exceptions. Previously, between 50 and 60 flight movements were permitted between 2300 and 0500. In addition, a new runway was opened at the same time, which altered the patterns of aircraft noise around the airport.

4.28 Over 200 participants living around the airport had their sleep measured in their own homes by polysomnography for three times (three to four nights on each occasion). A sound recorder simultaneously recorded all noise inside of the bedroom, and the loudness. The first measurements were taken in summer 2011, prior to the change in night flying restrictions and the new North West runway was opened. The other measurements were taken in the summers of 2012 and 2013.

4.29 Participants were questioned about their usual sleep habits and were excluded if suffering from conditions such as sleep apnoea, allergies that required medication, or if the family had children under the age of six and therefore potentially had disturbed sleep, or shift workers. In addition, participants were required to have regular sleep patterns. The people who participated in 2011 usually went to bed between 2200 and 2230 hours and got up between 0600 and 0630. In 2012 and 2013 people also took part that went to bed and got up on average one hour later. This allowed for analysis of shoulder hour periods between 2200 and 2300 and 0500 and 0600. For the years 2011 and 2012 the measurements were recorded by polysomnography, and in 2013 the researchers used a new method called vegetative-motor method, which combines Electocardiography (ECG) and body movements to determine awakenings. This method is less expensive and time consuming than traditional polysomnography, which requires multiple electrodes to be accurately attached to the participant.

4.30 The results are not yet available in English, but presentations of the work explained that findings indicated that there was no large difference in awakenings between 2011 and 2012, although the probability of awakenings was slightly higher in 2011. The main conclusions were that awakening frequency per night decreased from 2011 to 2012 from 2.0 to 0.8 for those participants who went to bed between 2200-2230. For participants who went to bed between 2300-2330 the frequency of awakening was 1.9 times per night, suggesting that going to bed earlier acts as a protective measure against noise. Comparisons were made for total sleep time, sleep onset latency, sleep efficiency and time spent awake and it was found that the overall quantity and quality of the sleep did not change between 2011 and 2012. Interestingly, the findings suggested that participants who exhibit a more negative attitude to aircraft noise show more objectively measured sleep disturbances. It is possible that this is related to noise sensitivity in those particular individuals.

4.31 The study also measured self-reported sleep quality as part of the annoyance work package. The findings indicated that there was less self-reported sleep disturbance in 2012 compared to 2011 which is unsurprising given the night flight restrictions, but there was an increase in early morning sleep disturbance between the two years. This suggests that the night flight restrictions do not adequately protect against self-reported sleep disturbance in the early morning shoulder hours. More detailed findings from the NORAH study will be available once the results are published in English and it should not be assumed that this is a comprehensive review of the study.

Chapter 5

Other health effects

Nocturnal effects

5.1 Elmenhorst et al (2010) examined the effects of nocturnal aircraft noise in both laboratory and field studies on cognitive performance the following morning. The study of next day cognitive effects of night-time aircraft noise is rare and has previously shown inconsistent results, with some findings suggesting that the number of aircraft noise events is an important contributor to next-day effects, and others describe performance decrements related to the maximum SPL or LA_{eq} experienced during the previous night. Other studies have found no association between aircraft noise exposure and next-day cognitive performance.

5.2 This study was designed to include a large sample and a wide range of number of aircraft noise events per night, maximum SPLs and LA_{eqs}. The presence of both laboratory and field data also allows for direct comparisons in the data analysis from both settings. In the laboratory, 112 participants were exposed to aircraft noise during 9 consecutive nights. In the field, 64 participants were examined during 9 consecutive nights in the vicinity of Cologne/Bonn airport. Reaction time, signal detection performance and subjective task load were recorded.

5.3 The results indicated a significant association with aircraft noise LA_{eq} levels and impaired performance on the Psychomotor Vigilance Test (PVT) in the laboratory study ($p = 0.0014$). Mean reaction time in PVT was 241.0 ms (±2.0 SE) under baseline conditions (day 2) and increased up to 245.9 ms (±2.5 SE) at day 11. Reaction time improved immediately to 242.3 ms (±2.8 SE) after one recovery night (day 12). The results from the field study indicated that one model including LA_{eq} and time in study yielded significant results. Mean reaction time increased with LA_{eq} ($p = 0.0284$) and with time in the study ($p = 0.0008$).

5.4 Interestingly, in the laboratory study reaction times on the Memory Search Task (MST) significantly decreased during the study under noise conditions ($p = 0.0083$), and increased again following one night of recovery sleep. However false alarm rates also increased along with faster reaction times over the course of the study. In the field study the time of the study was significantly associated with false alarm rates, with increased linearly and significantly from day to day ($p = 0.0046$). Mean reaction was not affected in the field.

5.5 There was a cumulative performance loss in both the laboratory and the field settings, with mean reaction time on the PVT increasing, and the probabilities for lapses increasing in the laboratory study. Due to the recovery nights in the laboratory, the researchers could show that mean reaction time in PVT increased depending on the LA_{eq} level of the previous night, and immediately recovered after one night without noise. The authors suggest that observed changes in MST could hint at a change in working strategy which causes the participants to work faster but less accurately. That could be a consequence of nocturnal aircraft noise as well as a mere response to the repetitive nature of the task during the study.

5.6 The authors propose that the results hint at changes in physiological processes due to nocturnal aircraft noise exposure. Only healthy adults were included, however, the researchers infer that the effects of nocturnal aircraft noise may result in stronger impairment in vulnerable groups such as children or people who are ill.

Psychological factors and annoyance

5.7 Kroesen et al (2010) investigated the effects of psychological factors on aircraft noise annoyance in an attempt to determine the direction of causality. The study took place around Schiphol airport in Amsterdam with randomly sampled residents who were living within the 45 L_{den} contour around the airport. The data were gathered in two surveys conducted in the periods April 2006 (n = 646) and April 2008 (n = 269). The rationale for this study is that cross-sectional study methods are usually used to examine attitudes towards aircraft noise. In these cases, since the independent and dependent variables are measured at the same time, the time precedence (i.e. X comes before Y in time) cannot be fully investigated and as such the direction of causation remains uncertain. There is still the question of whether the investigated social-psychological factors cause aircraft noise annoyance, or vice versa. Natural experiments, such as the closure of a runway can counteract this, but those instances are rare.

5.8 In this study the aim was to determine the direction of causality between 13 social-psychological factors and noise reaction. A Structural Equation Model was estimated based on repeated measures panel data gathered from the residents. Using a panel model can provide experimental tests for the time precedence and also addresses the issue of chronological order. The authors chose this method with the aim of retaining both the advantage of a field study in terms of high external validity and the advantage of an experiment in terms of high internal validity.

5.9 The results indicated that that none of the paths from the psychological factors to aircraft noise annoyance are significant. However, surprisingly, two effects were found to be significant the other way around: (1) from 'aircraft noise annoyance' to 'concern about the negative health effects of noise' and (2) from 'aircraft noise annoyance' to 'belief that noise can be prevented.' This means that aircraft noise measured at time 1 contained information that can effectively explain changes in these two variables at time 2, whilst controlling for their previous values. Secondary results also show that aircraft noise annoyance is very stable through time and that change in aircraft noise annoyance and the identified psychological factors are correlated.

5.10 The authors suggest that the direction of causality between aircraft noise annoyance and possible social-psychological factors is important for noise policy as the policies aimed at these factors can only be effective if the direction of causality is confirmed to be from such factors to aircraft noise annoyance. They propose that if, for example, personality traits can be found to be dominant in the explanation of individual differences, then more individually tailored noise policies would be preferable.

Noise and pregnancy

5.11 Hohmann et al (2013) reviewed the literature on chronic noise exposure and health effects during pregnancy and early childhood. The effects of noise on children are reviewed in Chapter 2 of this report, so this section will report only the findings during pregnancy. Twelve papers on pregnancy/birth outcomes were included, with samples ranging from 115 to 22,761. The papers focussed mainly on occupational noise, but have been included in this report due to a lack of research into aircraft noise specific effects on pregnancy. The aim was to evaluate studies on the association between chronic noise exposure during pregnancy and birth outcomes and the health of foetuses and infants (birth outcomes).

5.12 Six pregnancy cohort studies and four case-control studies examined birth outcomes and looked at occupational noise. One study additionally assessed environmental noise exposure and two cross-sectional studies examined the impact of chronic aircraft noise.

5.13 The results of the review indicated that chronic occupational noise exposure did not seem to be associated with birth weight of newborns, congenital abnormalities and pre-term foetal growth. The results on aircraft noise exposure and birth weight was inconclusive, with one of the studies (Schell et al, 1981) reporting a non-significant partial correlation between aircraft noise and gestational length. The other study by Knipschild (1981) found a significant negative association between aircraft noise and birth weight between non-exposed women and those exposed to 65–75 dB LA_{eq} (day/night).

5.14 The authors explain that due to the limited quality of most studies and a high variation in exposure and outcome assessments, final conclusions on the association between chronic noise exposure and paediatric outcomes cannot be drawn. They suggest that future studies should examine different noise sources, locations and time of day, considering the noise exposure at each location. Information on subjective noise annoyance and noise sensitivity should also be collected by self-report in addition to objective assessments. There is a particular need for high quality long-term prospective studies on the impact of chronic noise exposure on paediatric outcomes with more advanced outcome-exposure assessment and strong analysis strategies. Attention also needs to be given to potential confounders such as opening/closing of windows, insulation and duration of noise measurement in any future studies.

5.15 Ristovska et al (2014) also published a review of reproductive outcomes associated with noise exposure. This review included much research on occupational noise, but there were some epidemiological studies that examined aircraft noise and birth outcomes. A study from Japan (Matsui et al, 2003) found significant risk for low birth weight for mothers exposed to aircraft noise above 85 dBA. Another large population base cohort study from Canada (Gehring et al, 2014) found adverse effects of road traffic noise exposure and for all transportation noise associated with term birth weight and term very low birth weight. The noise effect on term birth weight was largely unchanged after adjustment for air pollution. Two smaller studies with lower quality scores also saw higher risk of low birth weight with higher noise exposure. A further two studies investigated correlations not risks, finding associations with birth weight in female but not male babies (Schell, 1981) or no association with low birth weight (Wu, 1996).

5.16 The authors explain that there is therefore supporting evidence for associations between low birth weight and noise exposure including from the better designed and larger occupational and epidemiologic studies, although they caution that associations were not consistently found across all studies and the total number of studies to date is small. Findings and conclusions for low birth weight differ with conclusions of Hohmann's review because this review included one large population based cohort study published after the Hohmann review, one large study from Japan and one case control study from China which were not included in that previous systematic review. These three studies gave supportive evidence for association between higher level of noise exposure and low birth weight.

5.17 The authors explain that there is a need for more research into environmental noise exposure and reproductive outcomes, and make the following recommendations for future research:

- objective and well-designed environmental noise exposure assessment;
- well-designed epidemiological studies;

- adjustment for confounding factors, such as life-style factors (smoking, alcohol use, drug use);
- characteristics of parents (parental weight and height, mother's age, race, ethnicity;
- socioeconomic status and pregnancy history for spontaneous abortion;
- congenital malformations;
- adjustment for air pollution when considering outdoor transportation noise; and
- standardised outcome definitions including use of birth weight < 2500 g for low birth weight, preferably with information on gestational age and birth less than 37 completed gestational weeks for preterm birth, in order to obtain comparable results.

Obesity

5.18 In 2014 a Swedish study by Eriksson et al was published that claimed a link between aircraft noise and obesity. The study was part of the longitudinal study on hypertension (Eriksson, 2010) and aimed to investigate effects of long-term (up to 10 years) aircraft noise exposure on body mass index (BMI), waist circumference, and Type 2 diabetes in over 5000 residents in Stockholm County.

5.19 The main finding was that there was an association between aircraft noise exposure and increased waist circumference after adjustment for individual and area-level confounders. The mean increases in BMI and waist circumference during follow-up were 1.09 kg/m^2 ± 1.97 and 4.39 cm ± 6.39, respectively. The cumulative incidence of pre-diabetes and Type 2 diabetes was 8% and 3%, respectively. Based on an ordinal noise variable, a 5-dBA increase in aircraft noise was associated with a greater increase in waist circumference of 1.51 cm; 95% CI: 1.13, 1.89; fully adjusted.

5.20 The authors found that this association appeared particularly strong among those who did not change their home address during the study period, which may be a result of lower exposure misclassification. However, no clear associations were found for BMI or Type 2 diabetes. In addition, sleep disturbances did not appear to modify the associations with aircraft noise.

5.21 Although this study attracted media attention due to the public interest angle, there are several limitations that must be taken into account when interpreting the results. Firstly, the study has a narrow range of exposure and a small number of highly exposed cases. This was particularly evident for Type 2 diabetes where only 47 cases had ever been exposed to aircraft noise, and only

26 cases exposed at ≥50 dBA. Therefore, the associations between aircraft noise and pre-diabetes and Type 2 diabetes in this study are uncertain.

5.22 A further important limitation is the lack of objective data on exposure to noise from other sources, such as road traffic, railways, and occupation, which may be potential confounders. Another major issue with this study is the over-sampling of people with a family history of diabetes (50% compared to the average of 20-25% in the general population). The authors explain that although there was no significant difference found in the effects of noise exposure in those people with a family history of diabetes compared to those without, the associations between aircraft noise and BMI as well as waist circumference appeared stronger among those without family history of diabetes. It is cautioned that this could influence the possibility of generalising the finding to the population as a whole.

5.23 Two papers were presented at the ICBEN Congress in 2014 that also investigated the possible links between environmental noise obesity. Bente Oftedal from the Norwegian Institute of Public Health presented a paper on research into the association between exposure to road traffic noise and markers of obesity. The study used data from 2000 and 2001 from 15,000 participants who had measurements of weight, height, waist circumference and waist-hip ratios taken.

5.24 Road traffic noise was modelled (L_{den}) at the most exposed façade of each of the participants' addresses, and regression modelling was used to analyse the associations between road traffic noise and obesity markers. The researchers were particularly interested in noise sensitivity as a potential modifying factor, and the genders were analysed separately. The results indicated that there were no associations between road traffic noise and obesity markers in women or men. There was a significant interaction between noise level and noise sensitivity in women, but not in men. Road traffic noise levels was positively associated with waist circumference and body mass index in the highly noise sensitive women, but this was not found in men. The researchers suggested that noise sensitivity is an effect modifier in the association between noise and risk of obesity in women. This is an interesting area of research, and has not yet been studied with respect to aircraft noise.

5.25 A co-author of that study, Goran Pershagen from the Karolinsa Institute in Stockholm presented a paper at ICBEN on traffic noise and central obesity that included over 5000 participants living in Stockholm during 2002-2006 (same epidemiological data as Eriksson, 2010). This study included different noise sources; road, rail and aircraft noise at residential addresses (obtained from geographical co-ordinates and digital noise maps) and examined the individual noise sources, and combined effects.

5.26 The data was analysed using logistic and linear regression with adjustment for possible confounding factors. Statistically significant associations between traffic noise and waist circumference were found, with a 0.3cm increase per 5 dBA L_{den} for road traffic, 0.6cm for railway noise and 1.0cm for aircraft noise. When the combined exposures were examined, a noise level above 45 dBA was associated with an odds ratio for obesity of 1.9, and similar patterns for waist-hip ratio but there were no associations found for body mass index.

5.27 The authors suggest that noise may act as a stressor and lead to the increased production of cortisol and other stress reactions. Elevated cortisol levels can result in the storage of fat in reserves within organs, and thus contribute to central obesity rather than generalised obesity. This stress theory echoes that of Babisch's general stress theory for noise-induced health effects. The authors also propose that central obesity may be a potential mediator of noise effects on the development of cardiovascular diseases and diabetes and there is a particularly strong association with aircraft noise and central obesity and for those people who are exposed to multiple traffic noise sources.

Chapter 6

European Network of Noise and Health

6.1 The European Network of Noise and Health (ENNAH) was set up in 2009 and is the largest network ever established in this research area, comprising academic researchers and health workers throughout Europe. In total, 33 partners from 16 countries were part of this network.

6.2 The outcomes of this project serve to identify gaps in the current research on noise and health, and provide suggestions for the prioritisation of future directions in this field. An example of these is the inclusion of air pollution confounding variables in noise and health research, in particular for environmental noise and transportation noise studies where there is inevitably a level of air pollution as a result of the noise sources themselves, as well as supplementary sources.

6.3 The ENNAH network has provided opportunities for young researchers throughout Europe to collaborate across countries and work together. This is important for the future of research in noise and health and helps to gain consistency with approaches across Europe. In addition to this ENNAH has provided a valuable contribution to the noise burden of disease calculations for Europe.

6.4 Recommendations for future noise and health research included the need to strengthen existing relationships with the use of longitudinal studies to assess the long-term impacts of acute noise exposure. Increased research into noise intervention policies and their effectiveness in terms of health impacts and cost was also suggested as a future direction, together with a detailed assessment of future investment areas that would be most important to enhance current knowledge

6.5 The ENNAH project ran for two years, and had the following objectives:

- To review existing literature on noise and health with consolidation of existing knowledge and the identification of research gaps.
- Ensure most recent measures of noise exposure assessment are applied to health studies.
- Assessment of moderating factors such as air pollution and its joint effect with noise.
- Enhanced communication between researchers in the two areas (noise and air quality).

- Development of new designs for research on noise and health and to provide EU with new strategies.
- The set-up of an exchange programme for young researchers.
- Dissemination of results to a range of audiences.

6.6 The structure of the network was organised into work packages, with work package 1 being the management of the network, and led by Stephen Stansfeld, Queen Mary University of London. The main findings from the other work packages are summarised below.

Work package 2: Review of evidence

6.7 This work package was led by Anna Hansell of Imperial College, London. The main aim of this group was to conduct a thorough literature search on a broad spectrum of areas relating to noise. These included physiological, psychological and psychosocial effects of environmental noise. After consultation with the other work package members, the most relevant studies were included and ranked according to agreed criteria.

6.8 Several gaps in the literature were identified, including:

- the effect of combined sources (many reviews describe the effect of a particular noise source, but the combined effects of more than one source are not yet understood);
- changing noise characteristics (for example the effect of tone on annoyance);
- mechanisms of co-exposures;
- noise sensitivity;
- definition of vulnerable groups;
- distinction between short and long-term effects;
- the relationship between sleep disturbance and stress;
- the role of annoyance in health outcomes;
- the role of noise in social behaviour;
- habituation to noise.

Work package 3: Noise exposure assessment

6.9 This work package was led by Danny Houthuijs from the National Institute for Public Health and the Environment in the Netherlands. The main objectives of this stream of the project were to discuss the current practice of noise exposure measurement and of strategic noise mapping in Europe and its potential use of health studies, and to identify novel methods and advanced measurement techniques for noise exposure assessment in future studies.

6.10 Since the END required strategic noise maps and action plans to be produced in order to gain information relating to major roads, railways and airports in agglomerations for the year 2006, approaches and techniques to noise modelling and measurement have improved. As a result of the required noise maps, a large amount of information is now available that is of use in environmental noise and health research but it is considered important to examine the exposure indicators to enable valid assessments of noise exposures in relation to noise and health outcomes.

6.11 Some of the lessons learned from EU noise mapping include general issues such as the definition of agglomerations, relevant year and quality of data. It was suggested that in order to achieve a fair comparison between EU countries and a further insight into noise and health, in terms of modelling, noise exposure assessment in health studies requires higher quality mapping beyond that of END requirements. GIS data sets are a possibility for linking noise to health outcomes due to the large data sets.

6.12 One of the suggestions from this work package is the use of 35dB during the night and 45dB during the day for road noise to increase contrast in exposure for health studies. It is important to note, however, that this is very difficult to achieve for any noise source as the background noise will often exceed these levels, especially in urban areas, making it very challenging to separate the aircraft or other transport noise from ambient levels. Another suggestion from this work package is that individual levels rather than 5dB contour bands should be available and vice versa. In health studies cut-off values should be introduced at the lower end.

6.13 In addition it was recommended that noise assessment should be increased to other facades as well as the most exposed. In terms of metrics it was proposed that L_{den} and L_{night} may not be the most relevant descriptors for health research. There is a need for a broader variety of indicators such as L_{eq} for health endpoints or event characteristics, for example L_{max}, SEL, Number Above and Time Above.

6.14 Exposure indicators should consider the critical time window and location of exposure. For sleep, exposure measurements should be taken in the bedroom for the duration of the sleeping period. Although this is a valid suggestion in theory, in practical terms this is again very difficult to achieve and control for other noise sources and background levels.

6.15 The recommendation was made that cumulative noise exposure should be taken into account for health studies, such as years of residence and change in residence and/or in exposure. This is relevant, given findings from Hansell (2013), which suggested that length of residency is an important factor in the link between aircraft noise and cardiovascular disease.

Work package 4: Confounding and effect modifying factors

6.16 This work package was led by Goran Pershagen from the Karolinska Institute, Stockholm. This group had several aims. Firstly, to identify potentially important confounders/effect modifiers in studies on noise effects on health including air pollution and individual susceptibility factors such as lifestyle/environment and genetic factors. Secondly to propose strategies for the assessment, analysis and interpretation of the role of such factors in health-related noise research. The development of collaborative working relationships between researchers in areas relevant to the field was a further aim, as was the need to perform further analyses of the HYENA and RANCH data.

6.17 In addition to air pollution, confounders to cardiovascular effects of environmental noise include age, gender, SES, ethnicity, smoking, alcohol, weight and physical activity. Potential additional confounders are heredity, diet, hormones, noise from other sources and shift work. The group therefore suggest that the study of interactions should be given a high priority in future research into environmental noise and health.

6.18 This work package concluded that for cognitive outcomes, socioeconomic status is crucial to take into account. Coping factors and psychological restoration may also be important in this area of research. For cardiovascular outcomes, socioeconomic factors are generally important to consider but in both cases socioeconomic classification should consider individual and contextual confounding variables.

Work packages 5a and 5b: Measurements of health outcomes in epidemiological studies and European Health Impact Assessment

6.19 ENNAH's work package 5a was led by Francesco Forastiere of the Department of Epidemiology, Lazio Regional Health Service (Italy) and had three main aims:

- To discuss the improvement of the measurement of health outcomes relevant to noise research
- To get consensus on standardised methodologies to be used in future studies on health effects of noise
- To make recommendations for further research.

6.20 It was suggested that the instruments used to measure outcomes as a result of environmental noise should be specifically tailored according to the age group of the target population i.e. infants, children, adolescents, adults, and the elderly.

6.21 The emerging areas of research identified for specific age ranges were narrowed down to:

- Children – perinatal disorders, growth hormones, puberty, sleep disorders
- Adults – fertility, reproductive disorders, diabetes secondary hypertension
- Elderly – diabetes, transient ischemic attack, stroke

6.22 This group also suggest that the biological mechanisms of noise-induced health effects should be postulated before including a noise related health outcome. In practice, of course this may not always be possible as the causal pathways are not always fully understood due to the various possibilities of outcome.

6.23 It was highlighted that it is important to give due consideration to recall bias when analysing self-reported health or wellbeing responses, compared to the complexity of measurement-based research, which may result in a potentially lower response rate. Laboratory studies are important but this group suggests that field studies are essential in order to establish realistic conditions. In addition, it is recommended that more research is needed on the long term effects of noise.

6.24 New biological indicators proposed by this work package include prolactin (a secondary stress hormone), blood lipids, inflammatory markers and serotonin.

6.25 Work package 5b was led by Nino Kuenzli from the Swiss Tropical and Public Health Institute, with the aim to discuss methods for Health Impact Assessment (HIA) in Europe.

6.26 There is an existing framework for the calculations of Disability Adjusted Life Years (DALYs) for annoyance, sleep disturbance, and cardiovascular effects, but as annoyance is the largest burden, it was proposed that there is a need to incorporate more meaningful aggregated measures of health into the HIA, such as well-being and cardiovascular factors. DALYs are highly sensitive to the disability weighting attributed to them. This is important as it could potentially influence the outcomes of non-direct health impacts such as sleep disturbance and annoyance, both of which make up the largest proportion of burden in noise

HIAs so far. Caution is advised when evaluating the total burden from different health endpoints also, as there is potential for double-counting. Due to these issues, the work package recommends the development of more integrative objective and subjective quality of life outcomes. In addition it is recommended that vulnerable groups need consideration as part of the HIA process.

6.27 The work stream group also considered that the evaluation of impacts for different socio-economic groups, to take into account setting-specific co-exposures and environmental factors, is of special importance for future research.

Work package 6: New strategies for noise and health research in Europe

6.28 This work package was led by Stephen Stansfeld of Queen Mary University of London with the aim of developing new strategies for noise and health research as the primary outcome of the ENNAH project and considered current research challenges as well as future directions for this field.

6.29 Current research challenges include the need for refinement in estimated dose-response relationships for cardiovascular endpoints. Only disease specific morbidity and mortality is recommended to be included, as well as disease specific confounders in analyses. It is also recommended to prioritise clinical measurements over questionnaires, although standardised and validated versions of these should also be continued to be used. The group suggests that research emphasis should be on strengthening and updating the dose-response relationships for classical cardiovascular endpoints and environmental noise. It is further recommended that Ischaemic Heart Disease (IHD) (or coronary heart disease) should include myocardial infarction and hypertension with stroke as a new end point.

6.30 The importance of considering differences in day and night time noise exposure was discussed in this work package and there is the suggestion of possibly measuring noise levels inside the bedroom. As previously mentioned, practically this would be very difficult to control for as there would be such a range of individual differences in background noise levels and factors such as windows being open or closed.

6.31 There is a particular need for studies on the combined effects of exposure to traffic related air pollution and noise on the cardiovascular system and interaction effects between noise and other environmental stressors. Any future research in this area will need to clarify which component of air pollution is implicated in the various health effects studied.

6.32 It is recommended that access to a quiet side within a dwelling should be studied further in relation to health effects. In addition to this the modifying effects of shielding, room location, window opening, insulation, age, gender and other exposures (e.g. air pollution) and possible vulnerable groups warrant further study.

6.33 New, less studied, cardiovascular disease endpoints could include the measurement of stroke, long term cortisol measurement from hair, measurements of thickness in the carotid artery, non-dipping of blood pressure and heart rate variability.

6.34 The future needs in annoyance research include updating dose-response relationships, particularly noting the increase in annoyance over recent years. Indeed, the interaction between noise annoyance and other environmental annoyances remains a gap. There is a need to design a combined model of all the interrelations between noise exposure and annoyance and non-acoustic factors in order to further explore the pathways that exist between noise, annoyance and other health endpoints.

6.35 There is a requirement to distinguish between spontaneous and induced awakenings during noise-induced sleep disturbance. Sleep disturbance may also have effects on memory consolidation and performance at work the following day. It is also important that nocturnal noise exposure may contribute to the onset of other diseases.

6.36 The definition of vulnerable groups to sleep disturbance was discussed. Vulnerable groups may be defined by lower thresholds for disturbance and/or stronger reactions to noise. Groups that are thought to be vulnerable include children, those with existing ill health, insomniacs and older persons.

6.37 It is important to clarify the association and mechanisms that exist between sleep disturbance and disease; to quantify and compare the noise dose that would contribute to disturbed sleep with other factors e.g. light. Vulnerability needs to be examined in terms of noise sensitivity, light sleepers, old age; and there is a need to establish valid dose-response curves for cardiovascular response during sleep and noise.

6.38 Further research is also required on noise exposure during the day that might affect sleep. Future studies should also control for ‘normal’ arousals and heart rate variability during Rapid Eye Movement (REM) sleep stages.

6.39 Research priorities in mental health include longitudinal studies using standardised clinical interviews to measure psychiatric disorder. These studies should involve multiple, environmental and social stressors particularly focussing on high levels of noise exposure and accompanying mental health outcomes with hormonal and physiological measures.

6.40 There is a need to understand the burden of disease and disability-adjusted life years in relation to noise exposure and cognitive impairment. To this end, longitudinal studies are needed for understanding the causal pathways between noise exposure and cognition. The long-term consequences of aircraft noise exposure, during early school life, on later cognitive development and educational outcomes have not yet been studied and remain important for policy making decisions. It is recommended that greater understanding is needed of the mechanisms of working memory and episodic long-term memory in children in relation to noise effects.

Chapter 7

Summary and conclusions

7.1 This paper has examined research evidence published since 2009 relating to transportation noise, in particular aircraft noise and the resulting impacts on various health endpoints. These included cardiovascular disease, night-time effects on sleep disturbance, children's cognition, psychological effects, performance and annoyance. The paper also reports on emerging research areas and health impacts not covered above such as associations with metabolic outcomes (obesity) and foetal development.

7.2 Research showing an association with aircraft and road noise and cardiovascular disease measures continues to mature. There is emerging evidence to suggest that cardiovascular effects are more strongly linked with night time noise exposure as opposed to day or total (24hr) noise exposure.

7.3 With regard to night noise and sleep disturbance, there is growing recognition that average indicators such as L_{night} are insufficient to fully predict sleep disturbance and sleep quality and that use of number of noise events (LA_{max}) will serve to help understanding of noise-induced sleep disturbance.

7.4 With regard to aircraft noise and children's learning, further explorations of past studies have taken account of confounding factors not previously considered such as air pollution and concluded that these did alter the associations previously found. A number of studies, whilst reporting associations in primary school children, discover that the effects do not persist in secondary school aged children.

7.5 There is a greater understanding of the importance of accounting for confounding factors, in particular air pollution, which is often highly correlated with aircraft and road traffic noise exposure.

7.6 With regard to future research there is increased interest in incorporating the relative contribution of different transport noise sources and to also include the cumulative noise exposure in studies. The European Network of Noise and Health (ENNAH) has successfully drawn on European-wide expertise and research and has identified a number of gaps for future research considerations and will likely play a major role in this subject area going forward.

Appendix A

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Summary

This literature review was prepared for the Department for Transport as part of their consultation on the night flights regime to apply at Heathrow, Gatwick, and Stansted airports from 26th October 2014. The review aims to provide an overview of the main findings within environmental noise and health research, and includes the effects of sleep disturbance due to aircraft noise. The cost-benefit analysis of night flights is discussed in terms of previous methodology and proposals for future evaluation of the aircraft movements at night are put forward.

January 2013

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Contents

Glossary of Terms

A-weighting A frequency weighting that is applied to the electrical signal within a noise-measuring instrument as a way of simulating the way the human ear responds to a range of acoustic frequencies.

Adrenaline Also referred to as Epinephrine. A hormone and neurotransmitter and member of the catecholamine family, which, when released increases the response of the sympathetic division of the Autonomic Nervous System.

Alpha waves Electromagnetic oscillations in the frequency range of 8–12 Hz observed in the brain during periods of waking relaxation with eyes closed.

ANE Aircraft noise event

BCA Behaviourally confirmed awakening

Catecholamine Hormones that are released by the adrenal glands in situations of stress such as psychological stress or low blood sugar levels. They include adrenaline, noradrenaline and dopamine.

CBBN Continuous broadband noise

Cortisol Hormone produced by the adrenal gland that is associated with stress responses, increasing blood pressure and blood sugar and reducing immune responses.

dB Decibel units describing sound level or changes of sound level.

dBA Levels on a decibel scale of noise measured using a frequency dependent weighting, which approximates the characteristics of human hearing. These are referred to as A-weighted sound levels.

EEG Electroencephalogram - used to measure brain activity during sleep.

ECG Electrocardiogram – used to measure heart rate.

EMG Electromyogram – measures facial muscle tone during sleep to identify REM.

Endocrine Typical endocrine glands are the pituitary, thyroid, and adrenal glands. Features of endocrine glands are, in general, their ductless nature, their vascularity, and usually the presence of intracellular vacuoles or granules storing their hormones.

EOG Electro-oculogram – measures movement of the eyes during sleep to help identify REM sleep.

Ergotropic Those mechanisms and the functional status of the nervous system that favour an organism's capacity to expend energy, as distinguished from the trophotropic mechanisms promoting rest and reconstitution of energy stores.

IBBN Intermittent broadband noise

K-complex An EEG waveform that occurs during stage 2 sleep. They occur randomly throughout stage 2 sleep, but may also occur in response to auditory stimuli.

L_A The A-weighted sound level (in dBA).

L_{Amax} The maximum A-weighted sound level (in dBA) measured during an aircraft fly-by.

L_{eq} Equivalent sound level of aircraft noise, often called equivalent continuous sound level. L_{eq} is most often measured on the A-weighted scale, giving the abbreviation L_{Aeq}.

L_{night} Equivalent sound level of aircraft noise in dBA for the 8-hour annual night (2300-0700).

L_{den} Equivalent sound level of aircraft noise in dBA for the 24-hour annual day, evening, and night where the evening movements are weighted by 5 dB and night movements are weighted by 10 dB.

Noradrenaline
Also known as Norepinephrine. Part of the catecholamine family, with dual roes a hormone and neurotransmitter. A stress hormone, along with adrenaline, noradrenaline also underlies the fight-or-flight response, directly increasing heart rate, triggering the release of glucose from energy stores, and increasing blood flow to skeletal muscle.

PNdB Perceived Noise Decibels.

Polysomnography (PSG)
A comprehensive recording of the biophysiological changes that occur during sleep. The PSG monitors many body functions including brain (EEG), eye movements (EOG), muscle activity or skeletal muscle activation (EMG) and heart rhythm (ECG).

REM Rapid Eye Movement sleep. A stage of sleep characterized by rapid movements of the eyes, low muscle tone and a rapid, low voltage EEG signal.

SEL Sound Exposure Level in dBA, a measure of noise event level, which accounts for both the duration and intensity of noise.

Sleep Efficiency Index
The proportion of sleep in the episode potentially filled by sleep (i.e., the ratio of total sleep time to time in bed)

Sleep latency The length of time that it takes to accomplish the transition from full wakefulness to sleep, normally to the lightest sleep stage

SPL Sound Pressure Level.

SWS Slow wave sleep, characterised by low frequency, high altitude waves on the EEG and comprised of Stages 3 and 4 sleep.

Trophotopic The movement of cells in relation to food or nutritive matter. Energy expending.

TST Total sleep time

Vasoconstriction
Narrowing (constriction) of blood vessels. When blood vessels constrict, the flow of blood is restricted or slowed

VPC Ventricular premature contraction

WASO Wake time after sleep onset

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1 Introduction

1.1 Background

1.1.1 Sleep is ubiquitous across species, and is fundamental to health and wellbeing, providing a regular resting period and preventing fatigue. Functions of sleep range from restoration at the cellular level, to neuronal repair, and it even plays a role in memory consolidation. Although most people would appreciate that sleep is necessary for survival and normal functioning, it is difficult to study the functions of sleep as it actually occurs. More often, it is the effects of sleep deprivation, fragmentation and manipulation of the sleep-wake cycle that are prolifically studied to examine the functions of sleep. Sleep researchers have been aware for quite some time that noise disturbs the sleep cycle and can cause alterations in sleep architecture, changes in sleep stage, body movements, decreased sleep quality and even awakenings during the sleep period. Next-day effects also exist, including increased fatigue, decreased performance levels and a resulting negative effect on mood. Noise also acts as a stressor on the body and can produce autonomic responses in the sleeping person, such as elevated cortisol, adrenaline and noradrenaline levels, which are implicated in long-term health effects on the cardiovascular system.

1.1.2 The most obvious source of noise at night comes from transportation, such as aircraft flying overhead, rail noise and road traffic. Due to its intermittent nature, aircraft noise is deemed to be the most annoying of transportation noise, with road noise being the least likely to annoy. It is the aim of this review to examine the work specifically produced on the effects of aircraft noise on sleep disturbance and other health effects, to provide an overview of the area, past and current undertakings and potential methodologies for evaluating the cost-benefits of night flights in terms of health impacts.

1.1.3 It is acknowledged that uninterrupted sleep is a prerequisite for good physiological and mental well being. The WHO Guidelines conclude that sleep disturbance is a major effect of environmental noise and that exposure to environmental noise may cause primary effects during sleep (e.g. awakening), and secondary effects that can be assessed after night-time noise exposure (e.g. next day tiredness). WHO identify the elderly, newborn, shift workers and persons with physical or mental disorders as being particularly vulnerable to sleep disturbance.

1.1.4 A report (Porter, 2000) prepared for the UK Department of Transport by National Air Traffic Services Ltd, considered the potentially adverse effects of night-time aircraft noise on people and reviewed available evidence. Porter's review is summarised below and provides the basis for the summary of the scientific literature presented here; it is supplemented by findings published since 2000 and the conclusions of various other reviews.

1.1.5 Porter categorised the potential effects of night-time aircraft noise as:

- Acute Responses: immediate or direct disturbances such as sleep disturbance (e.g. awakenings, sleep stage changes), other physiological changes that coincide with the noise events (e.g. increase in heart rate or blood pressure, or immune system effects) or acute annoyance.
- Total Night Effects: aggregations of acute responses over a total night, such as sleep loss or frequent disturbances breaking up the general sleep pattern.

- Next Day Effects: short term effects of the acute responses and total night effects (e.g. next day tiredness, degradation of task performance, short-term annoyance).
- Chronic Effects: pervasive long-term consequences of continuing acute responses and next day effects. These are the same potential effects as discussed above in general terms (e.g. annoyance, cardiovascular and physiological effects, and mental health effects.)

1.1.6 The review will cover a wide range of noise effects on sleep, from the effect on the microstructure of the electroencephalogram (EEG); to obvious changes in sleep architecture and their implications for sleep quality, mood and performance. Field and laboratory studies will be compared, and the use of actigraphy versus polysomnography as a means of measuring sleep disturbance in large populations around airports will be discussed. The physiological implications of noise-induced sleep disturbance will be looked at, including the main stress hormone concentrations, heart rate and cardiovascular responses to noise. This highlights the importance of the neuroendocrine system in the recovery element of sleep function and is important to consider in terms of long-term health effects of noise disturbance. Due to aircraft flight exhibiting a high proportion of low-frequency noise, this is also included for further insight into the specific effects of aircraft noise on sleep disturbance. Suggestions for further work and a summary of current research into this area will be given.

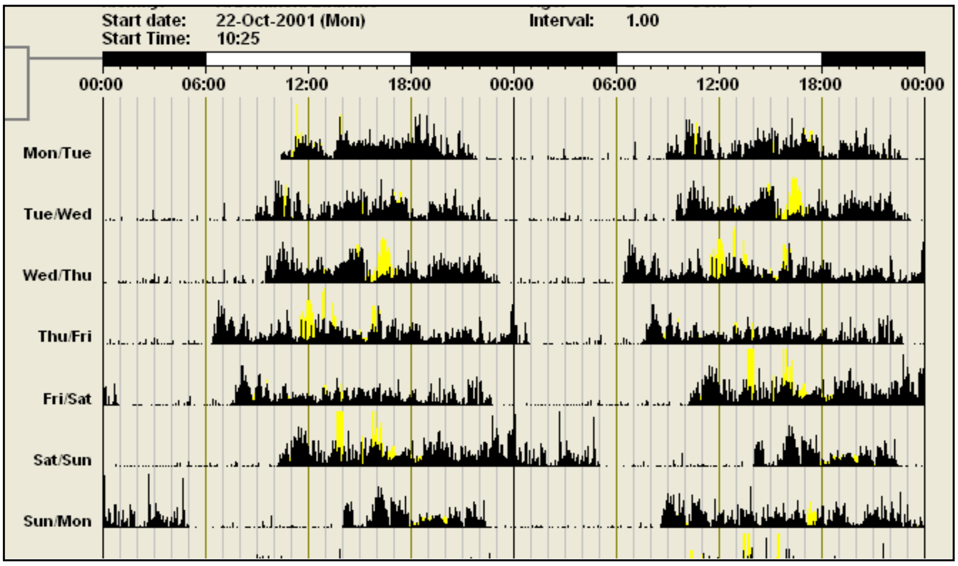
1.2 Sleep measurement

1.2.1 The most common and effective means of measuring sleep is by the Electroencephalogram (EEG). The scalp is “mapped” into specific sites and electrodes are attached accordingly, to measure changes in electrical activity in the brain as the subject sleeps. This provides a highly detailed record of the sleep period and charts progression through the sleep stages, changes within state, arousals and awakenings at the exact time at which they occur. Whilst providing the most accurate and detailed method of sleep measurement, it is usually easier to conduct whilst in a laboratory setting where the traces can be observed and electrodes can be replaced or reattached if necessary. It is also a relatively expensive and time-consuming method of sleep monitoring, and therefore is difficult to obtain results from large study samples.

1.2.2 A common non-invasive way of enabling sleep to be monitored in large samples is by actigraphy. The subject wears a small wristwatch sized monitor (actiwatch) on their wrist and is able to continue with their normal sleep/wake routine in their own home with no disruption. The actiwatches log movement at pre-prescribed intervals and produce a chart of activity (actigraph) and rest periods over the number of days in the study. However, because the actigraph gives an output of movement, and not brain activity, it is not always possible to correlate periods of rest with actual sleep. To corroborate actigraphy results it is common to ask subjects to keep a sleep diary throughout the study with details such as bed time, wake time, estimated sleep latency (time taken to fall asleep) and number and time of awakenings. The subjective sleep diary results, along with actigraphy software, can be used to calculate estimated sleep parameters such as sleep efficiency, fragmentation index, total sleep time, percentage time spent asleep etc. **Figure 1** shows an example of an actigraph.

1.2.3 Both methods of measuring sleep have been used in research into aircraft noise-induced sleep disturbance, and it is useful to separate these into field and laboratory studies.

Figure 1: Example of an actigraph. Dark bars represent activity, flat lines mean little or no activity, and yellow bars represent light exposure.



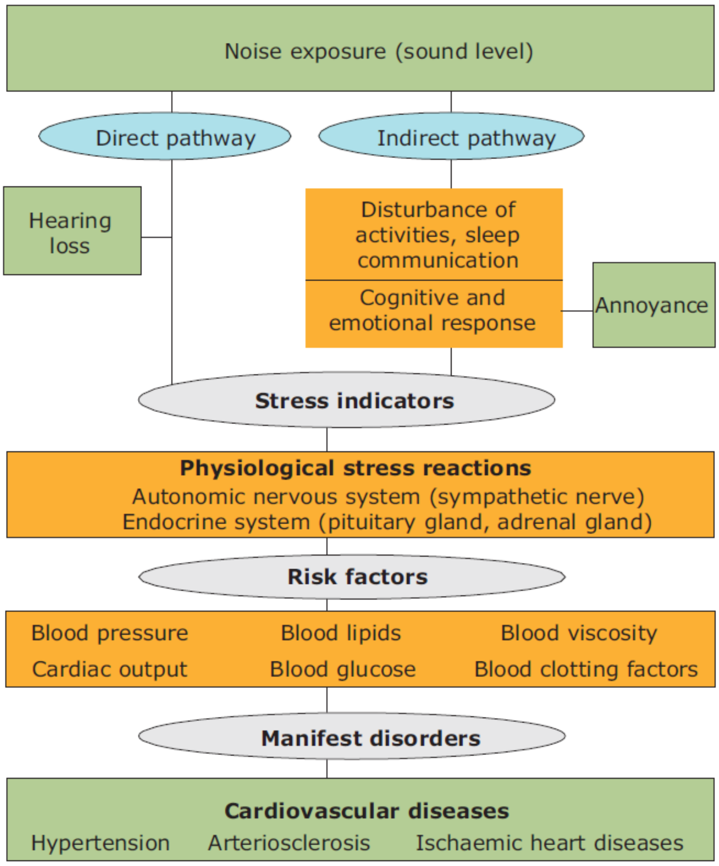
1.2.4 **Figure 2**, taken from Babisch (2002) summarises the effects of noise on the body.

1.2.5 Babisch (2002) explains that noise either directly or indirectly affects the autonomous nervous system and the endocrine system, which in turn affects the metabolic homeostasis (physiological balance) of the organism, including biological risk factors, and thus increasing the risk for manifest disorders in the long run. Indirect, in this respect, means that the subjective perception of sound, its cognitive interpretation and the available coping abilities play a role in physiological reaction. Direct, on the other hand, means that the activation of the regulatory system is determined by direct interaction of the acoustic nerve with other parts of the central nervous system (e.g. hypothalamus, amygdala). This is particularly relevant during sleep, where autonomous responses to single noise events, including changes in blood pressure and heart rate, have been shown in subjects who were subjectively not sleep disturbed.

1.2.6 Section 2 of this report reviews sleep disturbance research up to 1990, whilst section 3 reviews research after 1990. That year marks an approximate step change in magnitude and complexity of research studies into aircraft noise and sleep disturbance. Studies began to grow to include more subjects, more nights of data and record more information, including stress and cardiac indicators.

1.2.7 Section 4 summarises and reviews the health effects associated with sleep disturbance, including stress and cardiovascular risk and the effects on children. Section five discusses noise levels at which effects are considered to occur, including levels proposed for the protection of public health. Section six reviews research into monetising sleep disturbance and finally section seven provides on overall summary of the report.

Figure 2: Effects of noise on the human body



2 A summary of early studies into aircraft noise and sleep disturbance (1963 – 1990)

2.1 Introduction

2.1.1 In 1963, a report entitled "Noise", written by the committee on the problem of noise and commonly referred to as "The Wilson Report" after Sir Alan Wilson, Chairman of the committee, referred to the World Health Organisation's definition of health:

"Health is a state of complete physical, mental and social well-being, and not merely an absence of disease and infirmity"

2.1.2 The authors of the Wilson Report state that as people's well being is diminished by noise; there can be no doubt that noise affects health.

2.1.3 Even as early as 1963 the authors heard evidence presented to them, which highlighted the problem of aircraft-induced sleep disturbance. In a social survey conducted on people living near London Airport at this time 22% said that they were sometimes kept from falling asleep by the noise of aircraft, and the proportion rose to 50% with very high levels of noise. Results indicated that a higher proportion, also increasing with noise intensity, complained that they were sometimes awakened by noise. The authors noted that it is important to limit noise during the earlier part of the night, when people are falling asleep, due to the decrease in likelihood of awakening during deeper phases of sleep later on in the sleep period.

2.1.4 Work carried out by NASA in the early 1970s (LeVere *et al*; 1972) looked at the effects of the timing of subsonic aircraft flight over various stages of the night, and their effect on sleep. EEG recordings were used to establish the relative change in brain activity when exposed to aircraft noise at different times of the night compared to baseline, or quiet nights. Seven of the fourteen study nights, excluding the first three baseline nights, were selected at random to be the noise conditions. Each recorded jet flyover was played back to reach a loudness of approximately 80 dBA, with an approximate duration of 20 seconds, according to a predetermined random schedule over six hours of sleep. Changes in the EEG recordings were obtained for each third of the night and analysed to obtain the degree of response to the jet aircraft noise. The results indicated that the response to jet noise stimuli were significant for each portion of the night, and outlasted the length of the flyover by a considerable amount. Interestingly, the effects were more pronounced in the first and last thirds of the sleep period, with the mean change in brain activity being significantly lower in the middle two hours of the sleep duration (difference between early and middle $p = 0.047$; difference between middle and late $p = 0.016$). It is worthy to note that specific sleep stages or awakenings were not examined, rather a mean value of cortical arousal for each of the three epochs, with the early and late periods being those that are more likely to correspond to the times that subjects are more likely to be trying to fall asleep, and beginning to wake up. The authors concluded that this result in particular indicated that further investigation into the timing of scheduled aircraft noise would be worthwhile.

2.1.5 Follow-up work at NASA (LeVere and Davis; 1977) found that a 15 dBA reduction in aircraft flyover noise results in less sleep disturbance but only during fast-wave EEG activity. Slow-wave sleep, the highest proportion of which occurs in the first half of the night and is characterised by low frequency, high amplitude delta waves, was unaffected by this reduction in overall noise. Furthermore, although the effects of the 15 dBA reduction were noticeable on the EEG, it was not subjectively noticed by subjects in terms of self-assessed sleep quality. This finding questions whether simply reducing the noise level is beneficial to sleep; and still suggests that the timing of noise-exposure is likely to be pertinent.

2.1.6 Lucas also investigated the effects of aircraft noise on human sleep (Lucas, 1972) in terms of the response of sleeping subjects to the stimulus of simulated sonic booms and subsonic jet activated noise. The results suggested that children were relatively non-responsive to the stimuli, and in general the likelihood of awakening increased with age. The responses to the two types of stimuli did not differ, and the intensity of stimulus had little, if any effect on the frequency of arousal.

2.1.7 Cardiovascular effects of aircraft noise were also investigated around this time. Griefahn studied the effects of sonic booms on changes in pulse rate during sleep in 1975 (Griefahn, 1975). The sound level of the sonic booms were 83.5 dBA on average and were applied alternately either twice or four times per night for thirty nights. The booms were presented between 2200 and 0300. Following ten more noise-free nights, four nights of eight and sixteen booms alternately were presented. The interval between noises was 40 minutes in nights with two booms, 20 minutes in nights with four booms and in the nights with eight and sixteen booms, eight and four minutes respectively. The timing of the first boom was applied when a subject entered the deepest sleep stage. Pulse rate initially increased in frequency with a maximum in the fourth second, and then decreased below the level prior to the noise and then slowly increased to baseline level once more. No correlation was found between the intensity of the boom and the pulse reaction, or between the stage of sleep and the reaction. However, a highly significant correlation was found between the maximum post-boom increase of pulse rate and the rate prior to the boom, with the reaction becoming smaller as the pulse rate increased.

2.1.8 In 1977 the Minister for Companies, Aviation and Shipping commissioned a study into aircraft noise-related sleep disturbance (DORA Report 8008). The Directorate of Operational Research and Analysis (DORA) of the Civil Aviation Authority (CAA) conducted the study, and the three main aims were:

- To establish the nature and scale of all sleep disturbance from all causes around Heathrow and Gatwick airports
- To assess the significance of aircraft noise in causing sleep disturbance
- To investigate the relationship between exposure to aircraft noise and the degree of sleep disturbance.

2.1.9 Surveys were administered by post and face-to-face interview to a wide range of inhabitants living around Heathrow and Gatwick, together with an accompanying noise measurement programme and examination of the pattern of movements by aircraft at night. The main findings were:

a) Disturbance, such as difficulty in falling asleep, awakening during the night and tiredness on waking occurred frequently irrespective of aircraft noise. For example, on the designated night, at sites where little or no aircraft noise was heard, typically about a quarter of the population sampled reported difficulty in getting to sleep, while in response to a question on awakenings, a third of the sample said they awoke more frequently than once a week.

b) The researchers concluded that the measure L_{Aeq} ‘Equivalent Continuous Sound Level’, corresponding to the total noise energy produced by aircraft during the period 2300–0700, was a satisfactory measure of aircraft noise exposure i.e. it correlated well with sleep disturbance.

c) The total disturbance of sleep, irrespective of attributed cause, showed a slight increase at higher L_{Aeq} levels. For example, the proportion of people who claimed to wake more than once a week increased from 30% for L_{Aeq} of around 40 dB, to 40% at the noisiest sites with L_{Aeq} values of about 65 dB.

d) The disturbance attributed by respondents to aircraft noise increased more substantially as L_{Aeq} values increased i.e. the increase was greater than the corresponding increase in total reported disturbance. When asked about awakening, about half the respondents at the noisiest sites (65 dB L_{Aeq}) gave aircraft noise as a main cause compared with a tenth at the sites with least aircraft noise (40 dB L_{Aeq}).

e) Although total disturbance was similar at Heathrow and Gatwick, respondents tended to attribute their disturbance to aircraft noise to a greater extent at Gatwick than those at Heathrow.

f) The proportion of people who indicated difficulty falling asleep was higher at those sites where there was greater exposure to aircraft noise between 2200 and 2400.

2.1.10 The CAA/DORA study looked at subjective sleep disturbance with respect to aircraft noise, but valuable contributions into the effects of road traffic noise on sleep changes were also being made at this time, that could also be applied to aircraft noise. The long term effect of sleep disturbance due to traffic noise was investigated in people living near a main road and who had been exposed to noise for more than four years (Vallet *et al*, 1982). The findings indicated that young people show decreases mainly in sleep stages 3 and 4, and REM sleep deficits are seen in older people. In terms of cardiac responses, both maximum levels and average were important, with threshold levels of 37 dB L_{Aeq} and 45 dB L_{Aeq} at which a decrement in sleep quality is observed.

2.1.11 A different laboratory study examining the effects of traffic noise (Öhrstrom and Rylander, 1982) involved exposing subjects to intermittent and continuous noise during the night, finding a dose-response relationship between intermittent noise and subjective sleep quality. Similarly, this was also the case for body movements immediately following noise peaks during the nights with intermittent noise, and performance and mood were both decreased after this condition, but not following continuous noise nights.

2.1.12 Noise and social survey data were used from 673 respondents to develop a model of aircraft noise annoyance, including sleep disturbance, in the vicinity of Toronto International Airport (Taylor, 1982). The strongest direct effects were found for speech interference, attitudes toward aircraft operations, sleep interruption and personal sensitivity to noise.

2.1.13 This section has summarised the main contributions to the effect of aircraft noise-induced sleep disturbance understanding prior to 1990.

3 The effects of aircraft noise on sleep structure, alertness, mood and performance

3.1 Field Studies into Aircraft Noise and Sleep

3.1.1 In 1992 the findings of a study into aircraft noise and sleep disturbance, commissioned by the Department of Transport from the Department of Safety, Environment and Engineering at the CAA, were published (Ollerhead *et al*, 1992).

3.1.2 The objectives of the study were to determine:

- The relationships between outdoor aircraft noise levels and the probability of sleep disturbance.
- The variation of these relationships with time of night

3.1.3 Non-acoustical factors were also examined, such as age, sex, personal characteristics, and views of the neighbourhood, perceptions of sleep quality and the ways in which this might be affected by aircraft noise.

3.1.4 This study predominantly used social survey methods, with actigraphy and EEG recordings on a sub-group of participants, to enable validation of the actigraphy with respect to aircraft noise-induced sleep disturbance. The pilot study, conducted in 1990 involved a single site near Manchester Airport, and concluded that although actigraphy was a suitable measurement of sleep disturbance, additional sleep EEGs would be required to calibrate the results in the main study. It was found that the link between noise exposure and sleep disturbance was relatively weak and other factors (e.g. psychological) were identified as having an important role and required further investigation. In order to gain statistical significance, 50 subjects would need to be monitored for at least two weeks in the main study.

3.1.5 The main study used eight sites; two around Heathrow, Gatwick, Stansted and Manchester Airports, and were selected for a range of SEL, L_{Aeq} and N combinations. 200 subjects completed social surveys, with 50 of the subjects also completing 15 nights of actigraphy, sleep logs and daytime sleepiness questionnaires. From these 50 subjects, six had their EEG recorded simultaneously with the actigraphy for four consecutive nights at each site. In total almost 6,000 subject nights of data were collected, making it, at the time, the largest field study of aircraft noise and sleep disturbance undertaken.

3.1.6 The main conclusions to be drawn from the study were that actigraphy was a cost-effective, useful method of measuring sleep arousals in subjects participating in their own home, and that aircraft noise was a relatively minor cause of such arousals. Actigraphy was able to detect around 90% of awakenings of 10-15 seconds or more and can detect a large number of minor arousals, including brief awakenings, some sleep stage changes, and minor body movements. However, it should be noted that all of these characteristics occur naturally during normal sleep. Those subjects who reported awakenings often did not state a cause (26%) and of those who did, aircraft noise was found to be one of the minor causes, with less than one quarter of all subjects attributing this factor, on average about once every five nights.

3.1.7 The results suggested that below outdoor event levels of 90 dBA SEL (about 80 dB L_{Amax}), Aircraft Noise Events (ANEs) are most unlikely to cause any increase in measured sleep disturbance from that which occurs naturally during normal sleep. For those ANEs above this level, the average arousal rate was about 1 in 30, corresponding to a wakening rate of about 1 in 75.

3.1.8 Indications from the results measured in 15-minute periods showed that sleep arousals increase as a function of time throughout the night, which is consistent with the 90-minute duration of the sleep cycle. This finding suggested that people might show increased sensitivity to noise at certain times of the night. The authors concluded that sensitivity to aircraft noise is low during the first part of sleep, and increases until 0300-0400, and then decreases to a low level at the end of the night again, but it is important to remember that measurement is by actigraphy rather than EEG and so cannot detect all subtle changes in sleep structure. In general, males were found to be 15% more susceptible to disturbance (with or without aircraft noise), and other factors such as time of night, and the incidence of disturbance in the period preceding the ANE also have a bearing on the relationship between aircraft noise and sleep disturbance.

3.1.9 Horne, a co-author on this study, also published these findings in 1994 (Horne *et al*, 1994). It is important to consider that there are individual differences in terms of arousals in normal sleep, and so this is also the case in relation to aircraft noise. He reported small age and gender effects, which became apparent at about 180 minutes into sleep and increased towards the end of sleep, with males exhibiting more sleep disturbance than women, in general and as a result of aircraft noise. In terms of age for both genders, younger people (20–34yrs) moved around more during sleep, which is somewhat unexpected.

3.1.10 The findings from this field study suggest that the extent to which people experience sleep disturbance due to aircraft noise is much less pronounced in field studies where they are sleeping in their own home, compared to laboratory studies, where subjects are sleeping in unfamiliar surroundings and beds etc. The sleep of most subjects was largely unaffected by ANEs. The louder the ANE, the greater likelihood of an effect on sleep, but the response to louder ANEs (e.g. L_{Amax} > 80 dB, outdoors) was still very low on average (1 in 75). In this study, the most disturbing factors were given as young children, illness, needing to go to the toilet and bed partner, and aircraft noise ranked relatively low as a cause of sleep disruption.

3.1.11 A further publication (Horne *et al* 1995) arising from this important study, examined the patterns of spontaneous and evoked body movements during sleep in the actigraphy and EEG data. In addition to the above conclusions, the authors also reported that although movement increased over sleep, the likelihood of an ANE-evoked response did not, and they both differ in rhythmicity. Analysis of the EEG data in more depth revealed that the responsiveness to aircraft noise specifically, seemed to be lower during Rapid Eye Movement (REM) sleep, whereby surges in REM were associated with depressions in aircraft noise-induced movement, after the first hour of sleep and for the next 4.5 hours ($r = -0.57$; df = 17, $p < 0.01$), after which the association stops. The number of spontaneous movements was highly negatively correlated with Slow Wave Sleep (SWS). As SWS decreased the incidence of spontaneous movement (aircraft related or not) increased markedly ($r = -0.67$, df = 23, $p < 0.01$), with surges in SWS coinciding with troughs in spontaneous movement.

3.1.12 The low rate of awakening found by the study (1 in 75) has been strongly criticised. However, DETR (1998) used this value, together with the number of flights and number of people exposed by each flight between 2300 and 0700 to estimate that between 7,000 and 9,000 awakenings occur nightly at Heathrow airport.

3.1.13 Griefahn *et al* (2000) reported the results of a study investigating physiological, subjective, and behavioural responses to noise from rail and road. Participants were studied using social survey (n = 1,600) in eight areas exposed to road or rail noise, and actigraphy (n = 377) for two periods, each consisting of five nights. Subjects gave information on whether the windows had been open or close during the monitoring periods, and qualitative and quantitative aspects of sleep together with the results of a reaction time performance test were also collected. The only significant association was between the windows being closed and those people likely to live in areas exposed to road noise. No other difference was recorded in terms of performance, body movements and subjective assessment of sleep parameters. The authors suggest that varying the sound pressure levels in future research may be useful.

3.1.14 The suggestion that there is a circadian pattern of sensitivity to aircraft noise, as found by Horne *et al* was echoed by Hume *et al* (2003) who looked at the complaints caused by aircraft operations, in terms of noise level and time of day.

3.1.15 The authors looked at the data on complaints, noise monitoring, aircraft flight paths and movements to assess annoyance due to time of day at Manchester airport. The louder the noise the more complaints were generated, with twice the complaints at 110-114 PNdB (approx. 97-101 dB L_{Amax}) compared to at 74-79 PNdB (approx. 61-66 dB L_{Amax}). The hourly pattern in flight frequency and complaints were distinct, and complaints per aircraft movement for each hour showed a 24-hour pattern with the night flights causing on average nearly 5 times more than the rest of the day. Greatest propensity to complain was at 0100-0200 and the lowest at 0800-0900, which suggests a circadian pattern in sensitivity to aircraft noise.

3.1.16 Diamond et al (2000) undertook a study (by interview and questionnaires) of the perceptions of aircraft noise, sleep and health around major UK airports. They found that:

- Sleep disturbance attributed to aircraft noise was associated with greater health problems.
- Where night noise is relatively high, it causes annoyance to local residents and at two of the airports studied annoyance due to night noise exceeds that due to day time noise.
- Where noise is relatively high, between 10% and 20% of respondents reported having difficulty getting to sleep at night and being woken up in the morning.
- Very few people reported that their health was “extremely affected” by aircraft noise at night. However, between 30% and 60% of respondents at the various sites perceived their health to be “somewhat affected”.
- Respondents who reported long term or recent physical or mental problems, or stress in their job or in their life generally, were more likely to report their health was affected by aircraft noise at night.

3.1.17 Field studies have been used to assess sleep by actigraphy, but also to obtain large samples of questionnaire data relating to general health and medication in relation to aircraft noise exposure (Franssen, 2004).

3.1.18 A cross sectional design was employed to obtain survey responses from 11812 subjects living within a 25km radius of Schiphol airport. Associations were significant for all health indicators per 10 dBA increase in L_{den}, except for use of prescribed and frequent use of sleep medication or sedatives. None of the health indicators were associated with aircraft noise exposure during the night, but use of non-prescribed sleep medication or sedatives was associated with aircraft noise exposure during the late evening. Health complaints such as vitality, headache and tiredness were related with aircraft noise exposure, whereas other physical health complaints were not. The results suggested an association between community exposure to aircraft noise, and the health indicators “poor general health status”, “use of sleep medication”, and “use of medication for cardiovascular diseases”. The effect of aircraft noise on the cardiovascular system during sleep will be discussed in more detail in Section 4.

3.1.19 Michaud *et al* (2007) published a review of field studies of aircraft noise-induced sleep disturbance to examine the prevalence of disturbance. The effects of noise on sleep are mediated by many factors such as sound level, number, duration, time of occurrence, short- and long-term intermittency and consistency of distributions of aircraft noise intrusions into sleeping quarters. He looked at findings between 1990 and 2003, with regards to the ability of aircraft to:

- Interfere with the ability to fall asleep
- Curtail sleep duration
- Lessen the perceived quality of sleep
- Awaken people from sleep
- Increase bodily movements during sleep

3.1.20 Alongside work that has already been referred to (Ollerhead 1992; Hume 2003), Michaud *et al* (2007) describe the work done by Fidell (1995a, 1995b) which was a field study of 1-month duration on 27 people living near the main runway of a military airfield, and 35 subjects living near Los Angeles International Airport. A further 23 people living in neighbourhoods without appreciable noise exposure were controls. Subjects were asked to press a button on an awakening from sleep, for any reason. No actimetric or EEG measurements were made in this study, but questionnaires for subjective sleep quality, recalled awakenings, sleep latency and subjective tiredness were completed. Fidell *et al* attributed 16% of awakenings to noise events, and like Ollerhead found that the likelihood of awakening due to noise increased with time throughout the night. The subjective reports of tiredness in the evening were related to awakenings by noise events the previous night.

3.1.21 The mean indoor SEL for awakening was 81 dBA, and mean SEL that failed to awaken was 74 dBA. Taking into account a typical 15 dB for outdoor to indoor attenuation, these levels correspond to 96 and 89 dBA, very similar to the findings of Ollerhead et al (1992). Although greater SEL values were associated with a greater likelihood of awakening to aircraft noise, the slope of the relationship was not steep i.e. increase of 10 dB in SEL was only associated with a 1.7% increase in awakenings. Cumulative noise exposure throughout the night did not predict sleep disturbance and hence the study did not support adoption of L_{night} as a useful predictor.

3.1.22 Michaud summarises his review as follows:

> “The literature review of recent field studies of aircraft noise-induced sleep disturbance finds that reliable generalisation of findings to population-level effects is complicated by individual differences among subjects, methodological and analytic differences among studies, and predictive relationships that account for only a small fraction of the variance in the relationship between noise exposure and sleep disturbance. It is nonetheless apparent in the studied circumstances of residential exposure that sleep disturbance effects of night-time aircraft noise intrusions are not dramatic on a per-event basis, and that linkages between outdoor aircraft noise exposure and sleep disturbance are tenuous. It is also

apparent that aircraft noise-induced sleep disturbance occurs more often during the later part of the night; that indoor sound levels are more loosely associated with sleep disturbance than outdoor measures; and that spontaneous awakenings, or awakenings attributable to non-aircraft indoor noises, occur more often than awakenings attributed to aircraft noise."

3.1.23 Another study by Fidell (2000) used Behaviourally Confirmed Awakenings (BCA) and motility as indices of sleep disturbance, in Denver, Colorado. The study observed the sleep behaviour of subjects living near the airport, during a time when aircraft noise was reduced due to anticipated closure of Stapleton International Airport, coupled with an increase in aircraft noise for the residents living near to the new Denver International Airport, prior to opening. The age range of subjects was from young adults to the elderly and evenly distributed by gender. Morningness-Eveningness questionnaires were administered to assess diurnal preference i.e. whether people are morning or evening types, and actimetric and behavioural awakening measurements of sleep disturbance were made in 30-second epochs during 3 night-time periods: 0100-0130, 0300-0330, and 0500-0530. The percentage noise-induced behavioural awakenings (BCA) increased 0.25% per 1 dB increase in indoor SEL. For each increase of 1 dB in ambient L_{Aeq} levels, the actimetric and BCA responses due to noise events fell by 2-6%. Noise events were more likely to awaken men than women. Once the airport had opened, a statistically significant decrease in BCA was found, despite a large increase in indoor noise events. Prior = 1.71, after = 1.13. After closing of the DEN airport, BCA were not significantly different from each other, probably due to the levels of indoor noise events not changing notably (1.8 vs 1.64), although outdoor levels decreased from 58-46 dBA.

3.1.24 A further study by Fidell *et al* (2000) looked at sleep disturbance in 22 subjects with respect to anticipated increase in traffic prior to, and following the Atlanta Olympic Games. The number of noise events between 76 and 80 dB L_{Amax} increased slightly during the games. BCA were greatest prior to the games and fell from 1.8 to 1.2 per night during the games, and 1.0 afterwards. The indoor SEL predicted actimetrically monitored arousals, while outdoor SEL predicted BCA. Even at high noise levels most people were not awakened by aircraft overflights.

3.1.25 Passchier-Vermeer *et al* (2002) examined sleep disturbance in the vicinity of Schiphol airport in 418 subjects aged between 18-81 years, from 2200-0900 within bedrooms and at outdoor locations over 11 days. Sleep quality questionnaires were completed in the morning and evening, as were recalled awakenings due to aircraft noise, annoyance due to aircraft noise and motility. Actiwatch event markers were also used, whereby subjects pressed a button on the activity monitor to indicate they had been awakened. Subjective sleepiness ratings were taken five times a day in designated periods, and performance was measured by reaction time on a task to assess the effects of sleep loss on performance.

3.1.26 Aircraft noise effects were assessed on "instantaneous", 24-hour and long-term effects. Instantaneous effects included motility was defined as movement occurring within any 15-second interval of an aircraft noise event, and aircraft noise-induced onset motility as movement within a 15-second epoch immediately following an interval in which movement had not occurred directly before. The 24-hour scale included sleep period, subjective measures such as sleep quality and BCAs. Long-term effects looked at the mean motility over the 11 nights, questionnaire responses, and indoor and outdoor noise metrics.

3.1.27 The results can be summarised as the following:

Instantaneous effects: ANEs increased the probability of motility and the onset of motility. Instantaneous measures were influenced by the average equivalent indoor ambient sound level assessed over the 11 sleep episodes. When this was low, the probability of motility due to aircraft noise was higher, especially at the higher L_{Amax} levels. Motility probability also increased as a function of time after sleep onset. I.e. was higher at the end than at the beginning of the night. In terms of age, motility peaked at in those subjects at 46 years of age. The study concluded that the probability of motility and the onset of motility had threshold levels of 32 dB $L_{Amax, indoors}$ and 38 and 40 dBA $SEL_{indoors}$ respectively. Outdoor to indoor attenuation was 21 dB. Average thresholds were found to be about 15 dBA lower than by Ollerhead et al (1992).

24-hour effects: There was a significant increase in mean motility during sleep, number of BCA, and number of recalled awakenings due to aircraft noise as a function of indoor equivalent aircraft sound level, and number of aircraft during the sleep period time. Mean motility over the night increased when:

- Average noise within the bedroom not due to aircraft increased
- When the transmission loss from outdoors to indoors was low
- When subjects indicated a difficulty falling asleep due to aircraft noise
- And in those subjects who attributed awakenings to aircraft noise exposure

When aircraft noise was given as cause for trouble falling asleep, sleep latency was about 15 minutes. Perceived sleep quality reduced as motility increased but indoor aircraft sound levels and numbers of aircraft were not related to perceived sleep quality. Perceived difficulty in falling asleep had a stronger influence on perceived sleep quality, fatigue, the number of subjectively recalled awakenings, and the number of BCA. Aircraft exposure at night appeared to have no impact on reaction time as a measure of performance.

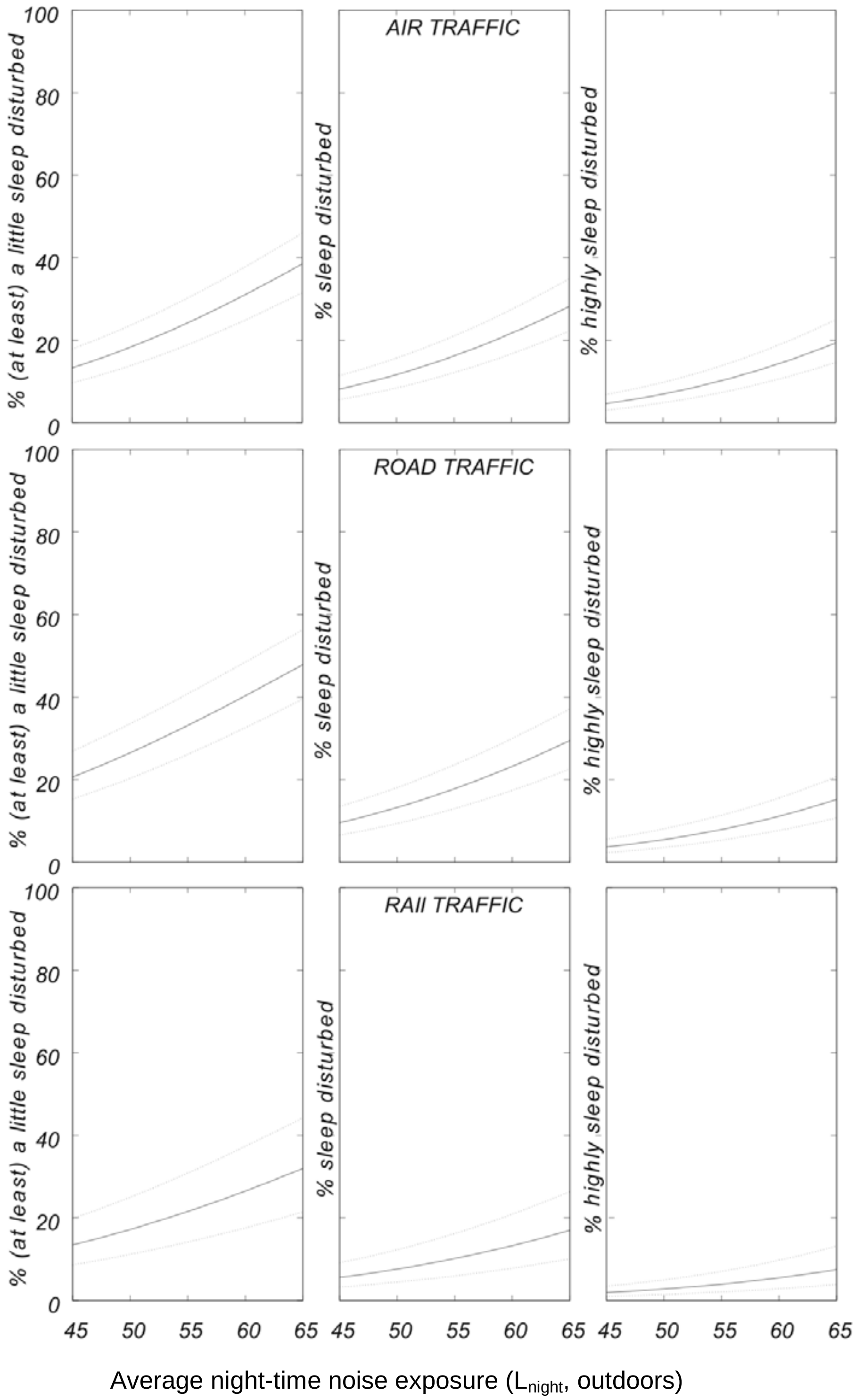
Long term effects: When the average sound level within the bedroom over the 11 days increased, mean motility was also higher and sleep latency increased. Mean motility also related to frequency of recalled awakenings, BCA, sleeping medication use, sleep quality, general sleep complaints, and number of health complaints.

3.1.28 Michaud (2007) explains that the findings of the studies are not conclusive in terms of the effects of aircraft noise on changes in sleep states that do not result in awakenings. Neither behavioural awakenings nor motility measurements are capable of detecting more subtle interference with sleep quality, e.g. brief changes in stage or "microarousals" that might also reflect a state of disrupted sleep. He suggests that there is some agreement in terms of spontaneous awakenings being more common than aircraft noise-induced awakenings in airport neighbourhoods; a small percentage of people are awakened by aircraft noise, and although the propensity for noise-induced awakening increases with time spent in bed this is confounded by the fact that sleep is more easily disrupted with time anyway, so noise events in the latter half of the night are therefore more likely to wake people than in the earlier half anyway.

3.1.29 Öhrström *et al* (2006) studied the effects of road traffic noise on sleep in children and adults in Sweden. Although this paper did not measure the effects of aircraft noise on sleep, it is useful to investigate the differences between adults and children. 160 children between the ages of 9 and 12, and 160 parents were interviewed. Half of the families were measured with actigraphy and sleep logs. In the parents, a significant exposure-effect relationship was found between road noise levels and sleep quality, awakenings, keeping windows closed at night, and perceived interference with traffic noise. For children a significant exposure–effect relationship existed between road traffic noise and sleep quality, and also daytime sleepiness. Children had a better-perceived sleep quality and fewer awakenings than parents; however actigraphy records indicated that the parents actually experienced better sleep.

3.1.30 Miedema and Vos (2007) have performed a meta-analysis of 28 datasets from 24 field studies into transport (aircraft, road and rail) noise and sleep disturbance. Re-analysis of existing data was performed because functions based on individual studies used different noise-exposure metrics and sleep disturbance variables, thereby making results difficult to compare. Contrary to previous studies finding that sleep disturbance correlated best with individual aircraft noise events, outdoor L_{night} was used for this analysis due to it being more widely available from existing study data. It was assumed that the outdoor-indoor differences and noise exposures at different sides of the building were treated as random factors. The data was translated to a scale of 0-100, and grouped into percentage (at least) a little sleep disturbed, percentage sleep disturbance, and percentage highly sleep disturbed (**Figure 3**). The confidence intervals illustrate that at the same average night time exposure levels, aircraft noise is associated with more self-reported sleep disturbance than road traffic noise, and road traffic noise is associated with more sleep disturbance than railway noise. The functions may be useful for evaluating night time noise exposures of a population (this analysis is not suitable for predicting individual reactions). At a given night time exposure level, self-reported sleep disturbance is maximal in people in their 50s, with road traffic and railway noise at age 50 years and for aircraft noise at age 56 years. This work has contributed to the debate on threshold levels for the protection of public health. L_{night} is also the night-time indicator required for mapping of major transport noise within the EU every five years, beginning in 2006.

Figure 3: Taken from Miedema (2007). The functions that specify three sleep disturbance measures (solid lines) in relation to the average night time noise exposure outside, and their 95% confidence intervals (broken lines) for air traffic, road traffic, and railway



3.2 Polysomnographic studies

3.2.1 EEG recordings allow detailed examination of fluctuations in brain activity as a response to noise, or any other stimulus. Changes in sleep stages, microarousals and the presence of alpha wave activity (8-12Hz) can mean that the quality of sleep is compromised; despite subjects being unaware that this is occurring.

3.2.2 Griefahn (2002) describes the primary effects of noise on sleep beginning with subtle changes in the EEG such as the presence of K complexes, followed by an increase in brain activity often accompanied with body movements and autonomous responses.

3.2.3 The effects of noise accumulate over the entire sleep period and increase the total time spent in shallow sleep. The secondary effects of noise are impaired subjective sleep quality, mood and performance.

3.2.4 It is not always possible to assume sufficient habituation has occurred in laboratory studies, as in the field subjects often woke less often, spent more time in deep/REM sleep, rated sleep quality as better and performed better after sound attenuation.

3.2.5 Griefahn (2002) explains that sleep disturbances increase with age and with self estimated sensitivity to noise, also personality traits, and diurnal preference (morningness-eveningness), with critical noise loads for continuous noises appearing to be between equivalent sounds levels of 37 dBA and 40 dBA.

3.2.6 Previous work conducted by Griefahn *et al* in 1976 was used to establish noise-polluted areas in Germany, and concluded that the night-time wake-up thresholds of aircraft noise was 60 dBA. However, Maschke *et al* (2004) re-evaluated this data and concluded that maximum noise levels of 48 dBA was a more accurate figure for defining waking thresholds at ear level in sleeping subjects.

3.2.7 Passchier-Vermeer (2003) carried out an analysis of data from seven studies (including those of Ollerhead, Fidell and Passchier-Vermeer identified earlier) into behavioural awakening as a result of exposure to commercial aircraft noise exposure to populations. She developed a method to convert onset of motility or EEG awakening to behavioural awakening. Her analysis concludes that the onset of behavioural awakening due to exposure to aircraft noise is 54 dBA SEL (indoor).

3.2.8 Raschke (2004) explains that the type of noise, frequency spectrum, information consent, duration of interval in repeated episodes, sequential number of sleep cycles passed through, exposure time in relation to the phase length of the circadian system, and age all have important roles in terms of the reaction to auditory stimulation. All functions have a modifying effect on the arousal threshold. Reaction to noise stimuli is multilayer, e.g. in response to sounds of 100Hz and 0.5-second duration, applied in the range of 43 to 80 dB with a 15cm distance, reactions can be seen in the EEG, momentary heart rate, continuously recorded non-invasive blood pressure, integrated sympathetic activity and tidal volume. All show short-time responses to the stimulus. Previous research suggests that the arousal reaction from sleep is mediated via the lucus coeruleus and the raphe nuclei in the brain, where Orexin (the hormone concerned with energy metabolism and food ingestion) plays an important role as hormonal transmitter for intact sleep-wake regulation functioning.

3.2.9 Raschke argues that micro-arousals are non-applicable as indicators of sleep disturbances and noise disturbance in noise effects research since they are valued at between 10 and 20 per hour in healthy persons anyway, and can be considered as normal in this range. This makes it difficult to separate out normal arousal during sleep, from those specifically induced by noise exposure.

3.2.10 The effects of low frequency noise on sleep (as exhibited by aircraft) were studied by Persson Waye (2004). Low frequency noise (20-200Hz) typically propagates with little attenuation through walls and windows, therefore making many people exposed to such noise in their homes. Sleep disturbance is commonly reported in studies into low frequency noise.

3.2.11 The review gives indications that sleep disturbance due to low frequency noise warrants further concern. Amongst other studies it was found that in a cross sectional study preformed on 279 people, no significant differences were detected in reported sleep among people exposed in their homes to flat frequency noise as compared to low frequency noise from ventilation/heat pumps (Persson Waye and Rylander 2001). It was found that fatigue, difficulty in falling asleep; feeling languid and tensed in the morning was reported to a higher degree among those annoyed by low frequency noise. Furthermore a significant dose-response relationship was found between reported annoyance and disturbed rest and degree of low frequency noise.

3.2.12 Those living in low-frequency areas have also reported higher incidences of chronic sleep disturbance, and depression compared to matched pairs not living in an area of low frequency. (Mirowska, 1998).

3.2.13 Although studies into aircraft noise are in the main performed on human subjects, sometimes it can be useful to investigate the effects on animals to gain insight into the processes behind the reaction. Rabat (2004) looked at the deleterious effects of an environmental noise on sleep and contribution of its physical components in a rat model.

3.2.14 The aim of this study was to confirm the effects of noise on sleep in a rat model and to determine the most deleterious physical component of noise regarding sleep structure.

3.2.15 Rats were exposed during 24-hours to environmental noise (EN) or artificial broadband noises (either continuous broad-band noise CBBN or intermittent broad-band noise IBBN). There have been conflicting findings in human fields studies as to the effects of one, or both CBBN and IBBN on REM and SWS, showing an effect on REM, SWS, none or both. The discrepancies may be down to individual variability in psychological sensitivity to noise, socioeconomic situation, differential cognitive processing of noise, or the use of pure tones.

3.2.16 All noises decreased both SWS and REM during the first hours of exposure. CBBN acted indirectly on REM through a reduction of SWS bout duration, whereas IBBN and EN disturbed directly and more strongly both SWS and REM. EN fragmented SWS and decreased the REM amount during the dark period, whereas IBBN only fragments REM sleep. Two physical factors are implicated, the intermittent and the frequency spectrum of the noise events, which both induce long-lasting sleep disturbances. An additive effect of frequency to intermittency tends to eliminate all possible adaptations to EN exposure, which could potentially lead to cognitive deficits. This may be worth considering when investigating the effect of noise on cognitive performance.

3.2.17 Basner and Samel (2004) at the DLR Institute for Aerospace in Germany conducted a large-scale, multi-stage study that aimed to investigate the acute effects of nocturnal aircraft noise on human sleep.

3.2.18 The authors reported that there have been conflicting findings in terms of assigning a threshold over which sleep disturbance is more likely to occur. Jansen (1995) assumed that the first changes in sleep depth induced by noise events are at a maximum level of 55 dBA, and awakenings at more than 60 dBA. However, these were individual observations without statistical evidence. Therefore the 60 dBA was assumed to be a theoretical benchmark from which to work. However in 1976 Greifahn *et al* tried to find an average value at which awakening was most likely and this figure came to around 60 dBA also, (SD 7 dB). Maschke *et al* did not agree with this and their calculation in 2001 gave a range of between 0 dBA and 48 dBA. These authors conclude from their new calculation that awakening is to be anticipated at 48 dBA with a probability of 95%. These newly calculated results contradict those derived by Maschke himself in 1992 where he deduced that the lower threshold for sleep stage changes should be set at a L_{Aeq} level of 36 dB, becoming particularly noticeable at L_{Aeq} 50-56 dB. These results were taken from a sample size of n=40 over 5 nights, but with no control group. A sub-sample of eight participants were exposed to sound over ten nights in order to examine catecholamine secretion (a measure of stress) in overnight urine samples. The results indicated a higher adrenaline secretion at 65 dBA than at 75 dBA. However, this was a small sample size and therefore it is difficult to attribute cause and effect.

3.2.19 The DLR study used a double blind crossover design. ANEs with differing distributions of L_{Amax} and frequency of occurrence were played back in pre-calibrated sleeping rooms while the physiological reactions were recorded. 128 subjects were investigated in the lab and 64 in the field, with an equal distribution of age, gender and prior exposure to aircraft noise.

3.2.20 Nights one and two were familiarisation and baseline nights, then subjects were exposed to 9 nights of aircraft noise with a varying distribution of L_{Amax} and rate of occurrence. Noise was played at regular intervals between 11.15pm and 6.45am. Eight subjects were exposed to the same pattern and level of noise per noisy night. The maximum level of an individual noise was between 50 and 80 dBA at the ear of the sleeper and the number of events per night ranged between 4 and 128 (i.e. intervals of between 3 minutes and 2 hours between noise events). These combinations were distributed over the 9 noise nights randomly and lead to continuous sound levels L_{Aeq} between 31.2 and 52.6 dB. The last two nights of the study were kept free of aircraft noise for comparative purposes.

3.2.21 EEG, Electro-oculogram (EOG), electromyogram (EMG), electrocardiogram (ECG), and finger pulse and respiration rates were all recorded. A test battery of memory and search tasks, reaction time, and a tracking task was also administered, along with questionnaires on mood, stress and recuperation, fatigue and flight-noise. The noise level indoors and outdoors was synchronised with the electrophysiological parameters to establish any relationship between aircraft noise and physiological reactions.

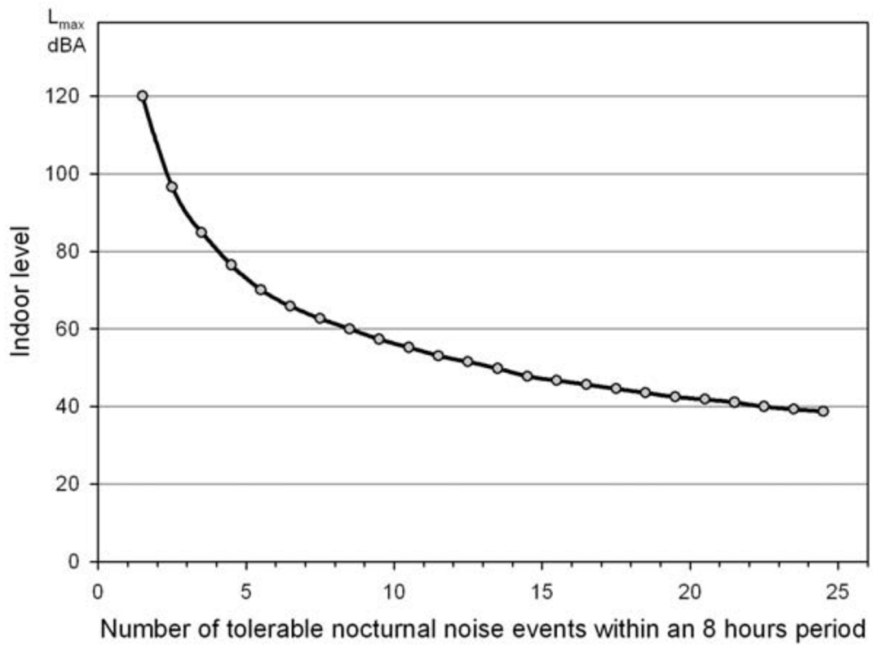
3.2.22 The difference in baseline and noise nights included a significant 9-minute reduction of SWS and an increase of stage 1 by 3.8 minutes. Therefore although total sleep time was not reduced significantly, the sleep architecture was considerably altered as a result of aircraft noise.

3.2.23 The percentage probability of awakening increased with L_{Amax} when the number of events was kept constant at 32 (2000 noise events were analysed in total). For a constant L_{Amax} level of 65 dB, the probability of awakening decreased with the number of noise events per night i.e. the more frequent the noise the less chance it will lead to an awakening.

3.2.24 As Griefahn and Spreng (2004) report, sleep disturbance from noise characteristically begins with a K-complex (a biphasic EEG wave formation accompanied by altered autonomic function such as increase in heart rate, constricted peripheral blood vessels), and also by body movements. Depending on the nature and intensity of the sound, this initial reaction is followed by a more or less long lasting desynchronisation of cortical activity that reach from a flattening of sleep up to awakening, thereby causing more or less extended partial sleep deprivations.

3.2.25 The authors developed two models that allowed the calculation of noise and number combinations that cause the same predefined risk with respect to intermittent noise (Griefahn 1992, Spreng 2002). The physiological model proposed by Spreng (**Figure 4**) refers to the admissible noise-induced release of cortisol in the normal range and its results match almost perfectly the noise and number relation determined for awakenings reported in the DLR study by Basner and Samel (2004).

Figure 4: The relation between the indoor maximum levels L_{Amax} and the number of tolerable noise events within an 8-hour period during the night. (Spreng 2002)



3.2.26 Based on this model, indoor evaluation limits were derived for intermittent noise as shown in Table 1 (Griefahn et al 2004) and applies to aircraft noise, which, concerning transportation noise, annoys the most and is true for Night-time Annoyance as well (Health council of the Netherlands 1999).

Table 1 Indoor evaluation limits derived for intermittent noise, taken from Griefahn et al (2004)

	Maximum level	Equivalent noise level
Critical Limit:	$L_{max,\ 22\text{-}6\ h}$ = 6 x 60 dBA *	$L_{eq,\ 22\text{-}6\ h}$ = 40 dBA
Protection Guide:	$L_{max,\ 22\text{-}1\ h}$ = 8 x 56 dBA	$L_{eq,\ 22\text{-}1\ h}$ = 35 dBA
	$L_{max,\ 1\text{-}6\ h}$ = 5 x 53 dBA	$L_{eq,\ 1\text{-}6\ h}$ = 32 dBA
Threshold Value:	$L_{max,\ 22\text{-}6\ h}$ = 23 x 40 dBA	$L_{eq,\ 22\text{-}6\ h}$ = 30 dBA

* Levels must not be exceeded

Unweighted distribution of air traffic over the entire night

	Maximum level	Equivalent noise level
Critical Limit:	L_{max} = 6 x 60 dBA *	$L_{eq,\ 8\ h}$ = 40 dBA
Protection Guide:	L_{max} = 13 x 53 dBA	$L_{eq,\ 8\ h}$ = 35 dBA
Threshold Value:	L_{max} = 23 x 40 dBA	$L_{eq,\ 8\ h}$ = 30 dBA

* Levels must not be exceeded

Critical Limits indicate noise loads that shall be tolerated only exceptionally during a limited time, health hazards and/or health impairments are no longer exc luded. *Protection guides,* below which health hazards are unlikely should not be exceeded. Excessions give reason for counter measures. *Threshold values* indicate physiological responses to noise.

3.2.27 The result of sleep fragmentation, as is often caused by the response to aircraft noise can often mean impaired performance the following day, even if subjects are largely unaware that their sleep has been disturbed. Studies into the deleterious effects of aircraft noise on performance are rare, but could be important in our understanding of the way in which noise disturbance affects the brain. Schapkin *et al* (2006) looked at executive brain functions following exposure to nocturnal traffic noise. The term “executive” refers to those processes that are governed by the frontal lobes and pre-frontal cortex in the brain, and are considered to be complex, such as planning, decision-making, execution and inhibition of an action and are known to be particularly sensitive to sleep disturbance (Jones and Harrison 2001).

3.2.28 Impairments of neuronal mechanisms underlying overt performance after sleep disturbance were investigated using event-related potentials (ERPs). When the awake, subject has to detect rare stimuli, a large positive brain response with a 300ms peak latency (“target” P3) and with the parietal maximum as well as a P3 of smaller amplitude over the frontal sites are registered.

3.2.29 Fragmented sleep or sleep deprivation reduces the amplitude and/or lengthens the latency of the “frontal” P3. These data suggest impairments in executive functioning probably due to deactivation of frontal brain areas after sleep disturbance.

3.2.30 It was proposed that normal people who were exposed to nocturnal noise might also have moderate lengthening of the P3 latency, and/or reduction of its amplitude. The authors also proposed that the components related to inhibitory control (Nogo-N2 and Nogo-P3) will be more affected by noise-induced sleep disturbance than those related to target categorisation (Go-P3) and this effect will be stronger with increasing task difficulty. Dose-dependent after-effects were expected on performance and/or on ERP. Aircraft noise was applied during the four study nights with 3 equivalent noise levels (L_{Aeq}) of 39, 44, and 50 dB and maximum values (L_{Amax}) varied between 50 and 74 dB.

3.2.31 20 subjects were grouped into good or bad sleepers. The performance and inhibition related components (N2, P3) were smaller and latencies more prolonged in the difficult task, compared to the easy one. This effect was more pronounced for Nogo than for Go trials. Nogo-P3 amplitude was smaller in Noise than in “quiet” conditions in the difficult task only.

3.2.32 In the difficult task, the Nogo-P3 latency was prolonged in bad sleepers compared to good sleepers. The Nogo-P3 amplitude was reduced in Noise as compared to “Quiet” conditions in bad sleepers only. Sleep quality in bad sleepers worsened steadily with increasing noise levels. No effects of noise or subjective sleep quality on performance were found. Inhibitory processes appear to be selectively impaired after nocturnal noise exposure. The task difficulty and perceived sleep quality are important factors modulating noise effects. The results suggest that nocturnal traffic noise increase physiological costs for inhibitory functioning on the day even if no overt performance decrement is observed.

3.2.33 Basner et al (2006) published the results of their polysomnographic field study carried out between 1999 and 2004, investigating the effects of aircraft noise on mood and performance. Participants were between 19 and 61 years, free from sleep disorders and had normal hearing thresholds for their age. EEG, EOG, EMG, ECG, respiratory movements, finger pulse amplitude, position in bed and actigraphy were sampled.

3.2.34 Noise levels and actual sounds were recorded in the subjects’ bedrooms at the sleeper’s ear, and outside at a distance of 2m in front of the window. The beginning and end of each event were marked, and continuous monitoring of the subject in line with the ANEs allowed for a direct comparison of reactions to the noise.

3.2.35 Awakenings increased with the maximum level of an ANE. Awakenings induced by ANEs larger than 65 dB L_{Amax} were relatively short. Those awakenings induced by ANEs larger than 70 dB L_{Amax} were longer than spontaneous awakenings, and those below 65 dB L_{Amax}.

3.2.36 The authors concluded that there should be on average less than one additional awakening induced by aircraft noise a night. Noise induced awakenings recalled in the morning should be prevented as much as possible, and no relevant impairments of the process of falling asleep again should occur.

3.2.37 Griefahn *et al* (2006) found a difference in reactions to road, rail and aircraft noise in a sample size of 32 who slept with weekly changes between the noise conditions.

3.2.38 Comparison between the quiet nights of the control group and the noisy nights of the experimental group showed a difference between SWS latency, TST and a decrease of SWS during the first sleep cycle.

3.2.39 Sleep efficiency index was lower for all noise conditions, as was time spent in SWS, and REM sleep, and wakefulness after sleep onset (WASO) was higher than quiet nights for all conditions.

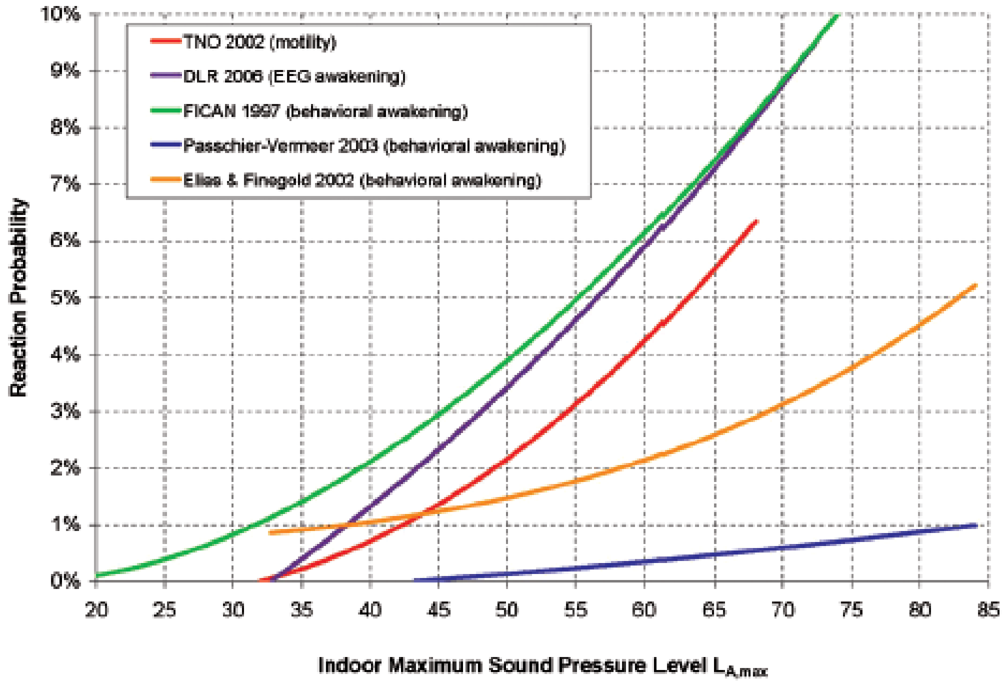
3.2.40 Most physiological variables showed strongest impairment under the impact of rail noise and smallest under the impact of traffic noise, with significance only reached on SWS latency, total time spent in SWS as well as for Stage 1 and wake, and SWS during the first sleep cycle. Sleep quality was significantly reduced and fatigue increased, irrespective of noise type.

3.2.41 Sleep quality decreased with increasing sleep latency, latency to SWS and increasing WASO, with decreasing TST, and increasing amount of wake and stage 1, and decreasing amount of time in REM.

3.2.42 Executive, frontal tasks were used and a decrement in performance was found following noisy nights (switch and non-switch tests) and this increased with noise load. The correlation between RT and time spent in SWS suggests a model in which work speed is causally related via shortened SWS to the impact of noise during sleep.

3.2.43 **Figure 5** is included is taken from (Griefahn 2006), which summarises five field study dose-response curves for a single ANE, and reactions of the sleeper (for example, EEG awakenings, body movements, behavioural awakening)

Figure 5: Comparison of five dose-response curves for a single ANE



3.2.44 The FICAN curve (Federal Interagency Committee on Aviation Noise) is interpreted as predicting the 'maximum percent of the exposed population expected to be behaviourally awakened'. The heart rate and blood pressure of subjects was not habituated in the field, and the variance in awakening behaviour was also due to noise sensitivity, age, gender, current sleep stage, elapsed sleep time etc.

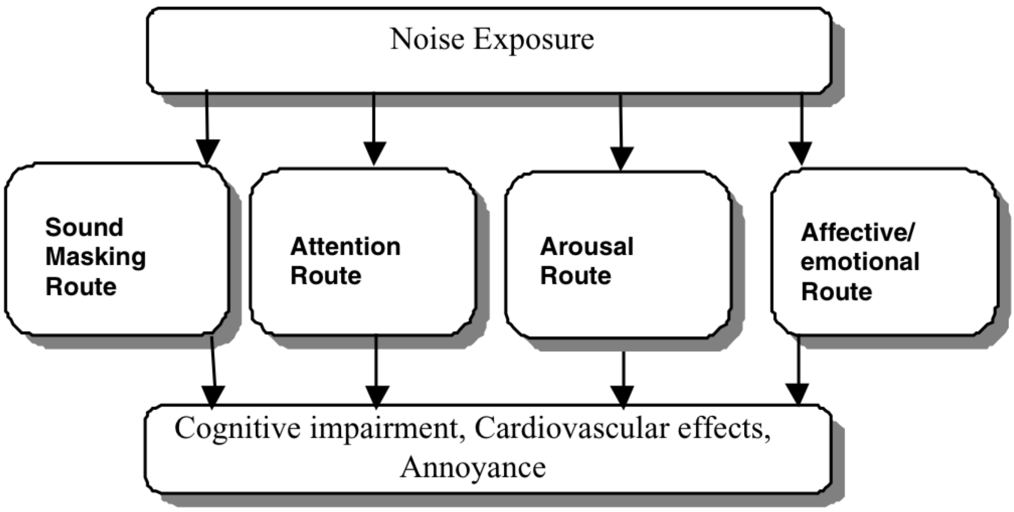
3.2.45 In terms of noise mitigation, the authors consider that traffic curfews should cover those times when most people are in bed trying to sleep. It is suggested that more information on the sleep habits of the population is required, and that shoulder hours may be need to be considered as an increase in traffic at these times could increase the effects on children, shiftworkers etc. It is concluded that in the future more research on noise mitigation measures is required, to assess their effectiveness in reducing noise induced sleep disturbance. The authors also suggest that future legislation should be based on both experimental studies of acute effects of noise exposure, as well as epidemiological studies on long-term health effects.

3.2.46 A recent study was conducted into the effects of aircraft noise on the macro- and microstructure of sleep, Basner *et al* (2007). 64 ANEs of maximum level of 45 dBA or 65 dBA were exposed to subjects over two nights, and compared to a baseline control night without noise. The authors found that the number of events per night increased in the order: awakenings, awakenings including changes to Stage 1 sleep, change to lighter sleep stage, and arousals, in that respective order, in control conditions as well as the two noise conditions. Arousals were four times as common as awakenings, irrespective of noise condition or control.

3.2.47 Miedema (2007) proposed a model of environmental noise disturbance as a stressor, impacting on behaviour (communication, concentration) and desired state (sleep and relaxation), with the ability to cope with such disturbance being important for health and well-being. The effects of noise depend on acoustical characteristics of the noise, such as loudness, time, pattern, and on aspects of the noise situation that may involve cognitive processing, such as expectations regarding the future development of the noise exposure, lack of short-term predictability, and a feeling of a lack of control over the source of the noise.

3.2.48 Miedema suggests that the model (**Figure 6**) involves four routes through which noise exerts its primary influence.

Figure 6: The four pathways through which the effects of noise are mediated. (Miedema 2007)



Sound masking Route:

This route reduces the comprehension of speech and masks speech, signals, music or natural sounds. International standard for the assessment of speech communication say that one-to-one conversation requires that the noise level does not exceed 41 dBA. At a distance of 4 m e.g. round a table or in a group, the noise must not exceed 29 dBA. These are very rarely achieved in urban areas and imply that the effects of environmental noise on communication are ubiquitous, especially in cities.

Attention Route:

Noise can negatively affect processes requiring attention. The effect of noise is probably most deleterious when impacting on working memory, and has been found to depend on the priority and difficulty of the memory task, and type of sound. Millar (1979) indicated that it is the rehearsal of the items in working memory that is negatively affected by noise. If noise detracts from rehearsal it can have negative effects on the ability to derive implications and restructure information into more meaningful clusters.

Arousal Route: Sleep

In field studies it has been found that the noise of a single event can cause instantaneous effects such as: extra motility, change in sleep state and EEG arousals, momentary changes in heart rate, and conscious awakening. The exposure-response relationship for conscious awakening has been assessed for civil aircraft (Passchier-Vermeer, 2003) Noise is described not by max sound level during the passage, but the total sound energy of the event (SEL). The effects of noise on sleep have low thresholds and the exposure-effect relationships increase monotonically. Noise is likely to be a dominant factor relating to sleep problems. More often it will cause a limited reduction in sleep quality that may not always be observed by the individual. Such noise-induced reductions of sleep quality may add to major causes of sleep problems that also appear to be mediated by increased arousal, such as social stress, medical stress, circadian stress and other environmental factors.

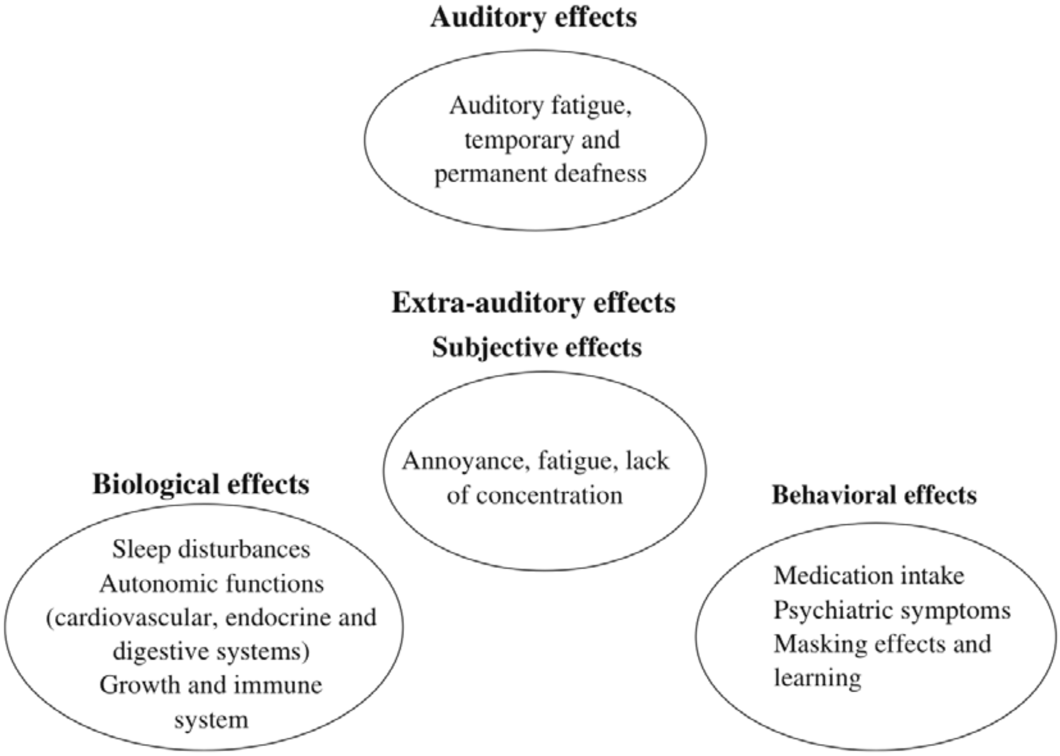
Affective-emotional route: fear and anger

As a result of noise affecting sleep, concentration, communication etc this frustration may lead to irritation or anger reactions. People high in trait anger may be more likely to show stronger emotional reactions when noise disturbs them. Fear can also be elicited with noise if it is associated with danger that threatens the individual. In this context it may be the worry of being in close proximity to an airport and therefore the concern over accidents that may induce fear, along with self-reported sensitivity to noise.

3.2.49 Miedema concludes that through masking, noise reduces comprehension, and through its effect on attention, noise affects the mental processing of information e.g. in reading. Through its effect on arousal, noise disturbs sleep, which may lead to fatigue, decreased performance, and depressed mood. Also, it may elicit emotional reactions when it interferes with behaviour or a desired state and may act as a stressor, or when it is associated with fear (aircraft noise). Such primary effects may in the long-term lead to annoyance, cognitive impairment, and/or cardiovascular effects. Chronic stress is also likely to be important in some long-term effects, in particular cardiovascular effects.

3.2.50 In the recent review on environmental noise, sleep and health Muzet (2007) explains the auditory and non-auditory effects of noise (**Figure 7**). Sleep disturbance is a non-auditory effect of noise. The input to the auditory area of the brain though the auditory pathways is prolonged by inputs reaching both the brain cortical area and the descending pathways of the autonomic functions. Therefore the sleeping body still responds to stimuli from the environment, although the noise sensitivity of the sleeper depends on several factors. These can be noise dependent e.g. type of noise, intensity, frequency, nose spectrum, interval, signification and the difference between the background noise level and the maximum amplitude of the occurring stimulus. Other factors are related to the sleeper, e.g. age, sex, personality and self-estimated sensitivity to noise.

Figure 7: Auditory and non-auditory effects of noise, taken from Muzet (2007)



3.2.51 The immediate effects of noise are seen as sleep disturbance, quantified by number and duration of nocturnal awakenings, number of sleep stage changes, and modifications in their amount. Also changes in the autonomic functions such as heart rate, blood pressure, vasoconstriction, and respiratory rate are observed.

3.2.52 Longer sleep latency and premature final awakening can reduce TST. Reports suggest that intermittent noises with maximum noise levels of 45 dBA and above can increase the time to fall asleep to 20 minutes. Combined with this, sleep pressure is reduced after the first 5 hours, therefore in the morning noise events are more likely to prevent the sleeper from going back to sleep.

3.2.53 Awakenings have a much higher threshold in deep sleep, e.g. SWS or REM, and a much lower threshold in lighter stages of sleep. The threshold depends on physical characteristics of the noisy environment (intermittent or sharp rising noise occurring above a low background noise will be particularly disturbing), as well as noise signification.

Sleep stage modifications

Nocturnal awakenings can be observed for an indoor L_{Amax} of 55 dB and above, and disturbance of normal sleep can be observed for maximum noise levels between 45 and 55 dBA. To protect noise-sensitive people, the WHO recommended a maximal level of 45 dB inside the bedroom, whereas for the same period the mean recommended level (integrated noise level over the 8 nocturnal hours: L_{night}) was 30 dB. SWS is the most restorative sleep stage, whereas REM is important for memory consolidation. Carter (1996) reported that SWS might be reduced in young sleepers subjected to intermittent noise. Also, Muzet has previously reported that REM sleep rhythmicity could also be affected by environmental noise exposure. It is common to see a reduction in SWS and REM and an increase in shallower sleep stages, which can become chronic and detrimental. Long-term studies of such reduced SWS are worth exploring and may prove to be important.

Autonomic responses

Heart rate changes and vasoconstrictions can be seen at much lower noise levels than are found to induce sleep disturbance and indicate that such disturbance can be felt when asleep even if there is no conscious memory of it the next day. The health effects of such responses can be cumulative, over a few thousand stimuli per night.

Secondary effects

Secondary effects include the subjective evaluation of sleep disturbance due to noise, such as complaints about sleep quality, delayed sleep onset, nocturnal awakenings, and early morning waking. They are often accompanied with increased sleepiness, tiredness and need for compensatory resting periods the following day.

Findings show that the subjective assessment of sleep quality does not accurately correspond to the objective measurement of sleep. When the number of noise events increase, the number of sleep modifications and/or awakenings also increases, but not proportionately. Porter (2000) found that noise heard at night was more intrusive and noticeable than noise heard during the day. This is due to reduced outside and inside background noise at night, and the circadian phase. It may also be a time of increased sensitivity to noise. Therefore it is wise to be cautionary when relying entirely on subjective reports of noise-related sleep disturbance due to their questionable validity.

Muzet (2007) reports that sleep disturbance occurring during the early part of the night and early morning prior to the natural time of awakening seem to be the most intrusive. This results in daytime sleepiness, fatigue and lower work capacity and increased accident rate. Fear of living under the flight path can also complicate the issue of accurately assessing subjective sleep quality as a result of noise, making the clarity of the relationship difficult to ascertain.

Other secondary effects

Stress hormones such as cortisol, noradrenaline and adrenaline are increased the following morning and there are also reports of cognitive impairment the next day.

3.2.54 Physiological sensitivity to noise can depend on the age of the sleeper. EEG changes and awakening thresholds are on average 10 dBA higher in children than in adults, however their cardiovascular sensitivity to noise is similar to older people.

3.2.55 In summary, there are conflicting findings, partly down to the difficulty in ascertaining a clear dose-effect relationship between noise and sleep disturbance, and the degree of interaction of confounding variables. The factors include noise characteristics, noise sensitivity, and the context of the environment.

3.2.56 Muzet (2007) suggests that future research should focus on the long-term effects of night-time noise exposure of different populations. A study of specific sub groups thought to be at risk, i.e. children, elderly, self-estimated sensitive people, insomniacs, sleep disorder patients, night and shift workers would be useful to assess differences between populations. Finally, the combined effects of noise exposure and other physical agents or stressors during sleep should be investigated to provide further understanding of the pathways in which noise disturbance effect sleep.

3.2.57 Brink (2009) produced a paper on determining awakening probabilities in night-time noise effects research. This paper was borne as a result of a German lawsuit involving Leipzig-Halle airport, which suspended its night-time curfew so it could be used as a freight-hub for a large logistics company. The surrounding controversy revealed that there was a lack of a common scientific standard for the probability of "noise-induced" awakenings. The aims included resolving the most problematic issues relating to the correct derivation of awakening reaction probability (as specified by EEG recordings) to noise events during sleep. It is explained that there is the need to know the probability of awakening spontaneously within a particular timeframe, as this information is required as well as the probability of awakening from noise. A time window is presented with representations of the probability of observed awakenings (P observed), spontaneous awakenings (P spontaneous) and additional i.e. awakenings that were not simply spontaneous (P additional). P induced was given as the probability of awakening *independent* of spontaneous awakenings. The problem of interdependencies of reactions was raised. For forecasting awakening reactions for a particular night-noise scenario, it is important to know whether the total probability of awakenings can be expected to be always the same, independently of a particular noise distribution over the night. This is problematic because of the likelihood of awakening is dependent on sleep stage, and increases with the time spent asleep. The other issue is that a reaction to a noise event, (awakening or not) may influence the micro- and macrostructure of sleep and therefore can also alter the probabilities of awakening at future events. It was explained that additional variables such as total sleep time (TST) could be modelled for night-time noise scenarios by a process based on assumptions about transition probabilities of sleep state, duration of state, and effects of noise properties of the noise events on these variables.

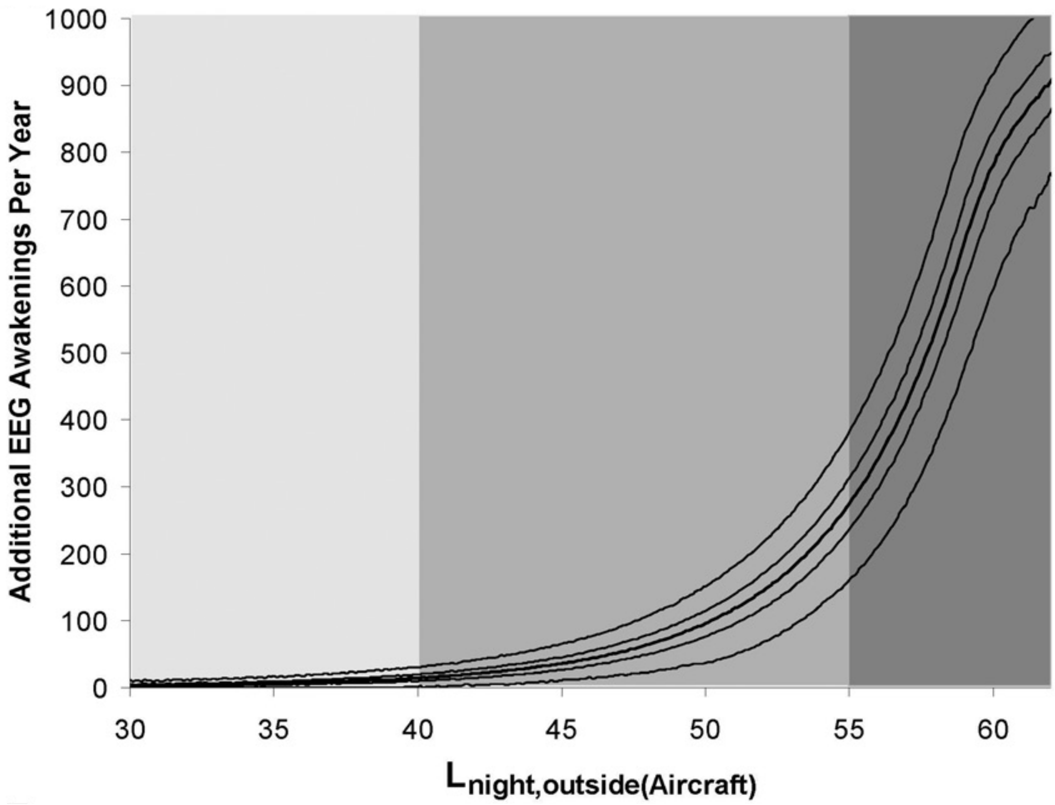
3.2.58 The Defra report 2009 concluded that no single dose-response relationship could be recommended for sleep disturbance as part of a valuation methodology. It is suggested that investigation into the linkage between the transient effects of noise on sleep and potential long-term chronic health effects is required.

3.2.59 The HPA report discusses the difficulty in obtaining a dose-response relationship between environmental noise and sleep disturbance due to the differences in results between laboratory and field studies, and also the issue of habituation to noise.

3.2.60 Finegold (2010) has also published a recent paper on sleep disturbance and aircraft noise exposure. This includes an explanation that there is no single noise exposure metric that is agreed upon for use in sleep disturbance research, and there are conflicting perspectives, for example, the use of SEL versus L_{Amax}. Although the WHO NNG (2009) and END recommend $L_{night,\ outside}$ to be used, in the USA SEL is still used as a metric for sleep disturbance with Finegold proposing a dose-response function based on the SEL of each event. The paper discusses the importance of the 'meaning of sound' as an important predictor of awakening, and highlights the current situation that there is little known about the long-term cumulative effects of intermittent sleep disturbance due to noise.

3.2.61 Basner et al (2010) discuss the mechanisms, mitigation and research needs of aircraft nose on sleep. This paper is also discussed in the health effects part of this report with reference to cardiovascular responses to aircraft noise at night. Sleep disturbance is examined, with data from the DLR field study on the effects of aircraft noise on sleep, being used to simulate single nights with 1 to 200 ANEs per night. Lnight and number of additional awakenings from aircraft noise (based on the DLR 2006 exposure-response curve in Figure 5) were calculated and used to predict the degree of sleep fragmentation. These results (taken from Basner et al 2010) are shown in **Figure 8**.

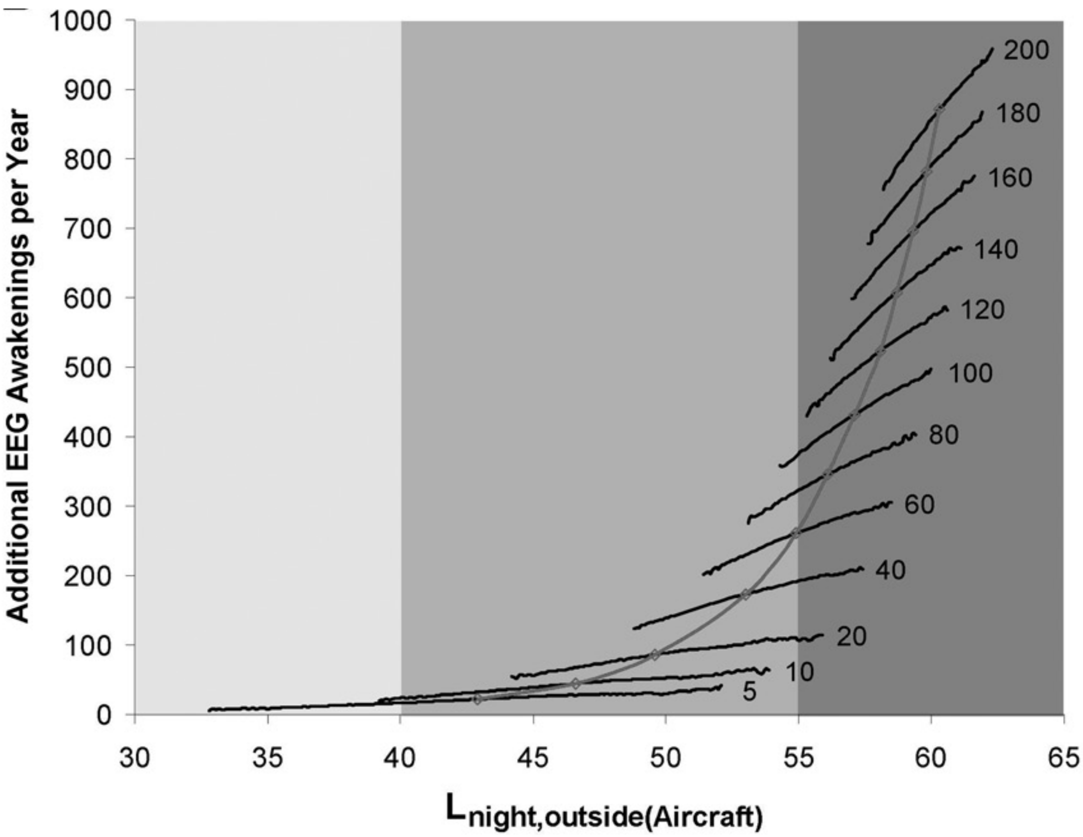
Figure 8 The average number of awakenings additionally induced by aircraft noise per year is shown depending on *L*night,outside. Altogether, 10 million eight-hour nights with 1 to 200 (1, 2, 3,…, 200) noise events randomly drawn from the DLR field study were simulated. The lines represent (from below to above) 2.5, 25, 50, 75, and 97.5 percentiles. (Basner et al, 2010)



3.2.62 The shaded part of the graph represents the recommended target and interim noise limits as given in the WHO NNG (2009) of 40 and 55 dB L_{night} respectively. These limits are discussed in more detail in Section 5 of this report, but results from this study do seem to support the recommendations from WHO for the given limits.

3.2.63 The number of noise events was also studied in terms of sleep disturbance. Findings showed that there were differences in the degree of sleep fragmentation depending on the number of noise events that contributed to a particular L_{night} level. This is shown in **Figure 9**, for example at 55 dB L_{night} the number of awakenings varies between just over 100 (at 20 noise events) to nearly 400 (at 100 noise events).

Figure 9 The average number of awakenings additionally induced by aircraft noise per year in relation to L_{night} and number of ANEs. The horizontal lines represent the median number of additional awakenings, with numbers on the right indicating the number of ANEs per night contributing to $L_{night,outside}$. The curve joins up the mid points for each number of events line.



3.2.64 The authors suggest that additional information on the number of noise events contributing to L_{night} would be useful in terms of allowing for a more precise prediction of the number if additional awakenings that could be expected.

3.2.65 A recent laboratory based study (Basner et al. 2011) examined the impacts of mixed transportation modes (air, road and rail) on sleep disturbance. 72 subjects were studied (32 male) for 11 consecutive nights with 0, 40, 80 and 120 noise events employed in a balanced design, in terms of number of noise events, maximum sound pressure level and equivalent noise load. The results showed that road traffic caused the most obvious changes in sleep structure and continuity whereas air and rail was considered more disturbing subjectively. This was attributed to road traffic noise events being too short to be consciously perceived by the subjects that had awoken in response to the event. The results also showed that while subjective annoyance was greater for aircraft noise, cortical and cardiac responses during sleep were lower for air compared to road and rail traffic. An interesting finding was that most (>90 %) of the noise induced awakenings merely replaced awakenings that would have occurred spontaneously, which helped to preserve sleep continuity and structure despite the noise. This suggests that within limits there is some homeostatic mechanism for internal monitoring and control of waking arousals (or maintaining sleep) that are allowed during each night‘s sleep.

3.2.66 Janssen (2011) investigated the number of aircraft events and motility during sleep. The background to this study was that both the WHO and EC advise on the use of the

L_{night} metric as the primary indicator for sleep disturbance. The author explains, however, that an important question for noise policy is whether from a public health perspective it may be of interest/advantage to use the number of events in addition to L_{night}. For example, for some effects it may be preferable to reduce the number of events above a certain threshold than to lower the overall exposure level of events. This study used data from Passchier-Vermeer's 2002 study in the Netherlands, and looked at the association between objectively measured sleep disturbance and the number of aircraft noise events with respect to mean motility during the sleep period. The researchers wanted to know whether motility can be predicted more accurately taking the number of events into account. The results suggested that an increase in SEL contributes more to motility than an increase in the number of events. However, it was also found that the influence of the number of events increases with increasing levels of the event. Janssen suggested that to reduce motility, it may be better to prevent events with high maximum sound levels, than to reduce the overall number of events.

3.2.67 Plante et al (2012) conducted a review of the evidence relating to aircraft noise and sleep disturbance. Studies were included based on quality and bias criteria and therefore many studies were not included due to methodological discrepancies or because they did not provide an objective measurement of noise levels. Nine studies met the inclusion criteria, eight of which were experimental, three were cross-sectional and one was an ecological study. The review summarised the design for each of the studies, noise events, measurements of sleep outcomes and findings. The authors concluded that aircraft noise exposure does impact on sleep disturbance and the deterioration of sleep outcomes based on the findings from moderate to high quality studies. As the sound levels increase, the probability of awakening increased and awakening times last for longer periods. In addition, individuals exposed to higher levels of noise have been found to have shorter periods of SWS, and sleep medication increased when aircraft noise events occurred in the evening. Gaps in the field were also identified, with the suggestion that research attention is given to the over 65s, people with chronic illness and pre-existing sleep disorders.

3.3 Summary

3.3.1 The majority of research into noise and sleep disturbance has concentrated on the relationship between individual aircraft noise event levels and the two principle characteristics of an ANE, the maximum level, L_{Amax} and the sound exposure level, SEL. Researchers have sometimes concentrated on indoor rather than outdoor levels, but appear to have ignored the fact that public policy has little control over outdoor-indoor attenuation levels, because, in all the but the highest noise areas, residents are free to open windows.

3.3.2 The focus has also been to identify the lowest observable threshold (L_{Amax}, SEL) at which to avoid effects.

3.3.3 Whilst SEL is a pre-requisite in the calculation of exposure metrics such as $L_{night,outdoors}$, it is seldom provided in addition to $L_{night,outdoros}$ as it varies with location and aircraft type. As a result, there has been a shift, at least within Europe, towards linking sleep disturbance to the more readily available $L_{night,outdoors}$ metric.

4 Health effects

4.1 Introduction

4.1.1 The World Health Organisation (WHO, 1968) defines health as follows:

> "Health is not merely the absence of disease or infirmity but is a positive state of physical, mental and social well-being."

4.1.2 This broad definition has been taken as the basis for including a review of various effects within this section.

4.1.3 It is universally accepted that exposure to high noise levels can induce hearing impairment, however at the levels of environmental noise exposure around civilian airports hearing loss in unlikely. This report therefore focuses on the non-auditory health effects of environmental noise, that is:

> "All those effects on health and well-being that are caused by exposure to noise, with the exclusion of effects on the hearing organ and the effects which are due to the masking of auditory information (i.e. communication problems)"

4.1.4 This section presents a summary of the scientific knowledge of noise and health under the following categories:

- Cardiovascular and Physiological Effects
    - Myocardial infarction
    - Hypertension
    - Ischemic heart disease
    - Stress
- Next day effects
- Noise and Children
- Night time specific effects

4.1.5 Noise can elicit a stress response in the body in the same way as other stressors. The normal stress response is a coping mechanism that occurs when the brain perceives a threat. Acute noise exposures activate the autonomic and hormonal systems, leading to temporary changes such as increased blood pressure, increased heart rate and secretion of stress hormones. Normally, these return to baseline levels when the noise ends or the person adapts. However, prolonged exposure to noise may have the potential, in susceptible individuals, to cause chronic physiological effects such as hypertension, ischaemic heart disease (IHD) and elevated stress hormone levels. Sustained elevated hormone levels may affect the functional integrity of bodily organs and tissues.

4.1.6 With regard to cardiovascular effects, the WHO Guidelines conclude that epidemiological studies show that these occur after long-term exposure to noise (aircraft and road traffic) with values of 65 to 70 dB $L_{Aeq24hour}$ – however the associations are weak. The association is somewhat stronger for IHD than for hypertension. The WHO identify that although the risks of noise having a negative impact on cardiovascular function are small, they are important because a large number of people are likely to be exposed to such noise levels.

4.1.7 The WHO NNG concludes that more research is needed regarding the association between aircraft noise and cardiovascular end points.

4.1.8 A literature review was undertaken of the scientific knowledge on the subject of 'environmental noise and health', with particular reference to aircraft noise. The World Health Organisation Guidelines for Community Noise ('WHO Guidelines' 1999) were taken as the basis for the review, and a literature search was carried out for key papers published after the WHO Guidelines and for review papers published since the late 1990s.

4.1.9 A number of review papers are referred to repeatedly throughout this section, these are:

- Health Council of the Netherlands (1999). Public Health Impact of Large Airports. ('HNC Review')
- Health Canada (2002). Noise from Civilian Aircraft in the Vicinity of Airports, or Human Health - Noise, Stress and Cardiovascular disease. ('HC review')
- Health Council Australia (2004). The Health Effects of Environmental Noise - Other than Hearing Loss. ('ECA Review')
- Various reviews undertaken by Stansfeld and co-workers

4.1.10 Two papers have more recently been published in this area; the first was commissioned by the Department for Environment, Food and Rural Affairs (Defra) on behalf of their Interdepartmental Group on Cost and Benefit (IGCB) into an estimation of the dose-response relationship between noise exposure and health effects; the second is a Health Protection Agency (HPA) report entitled Environmental noise and health in the UK.

4.1.11 The Defra publication (2009) is authored by Bernard Berry and Ian Flindell, and comprises four main aims:

- To identify a comprehensive list of potential adverse health impacts from noise and review the current state of evidence for each of the impacts;
- Where a robust evidence base exists, to recommend quantitative links (dose-response functions) for the impacts of noise on health which could be applied in the UK;
- Identify any emerging adverse health impacts that should be kept under review for future consideration in evaluation; and
- Identify any structural challenges to developing and maintaining strong quantitative links between noise and health outcomes

4.1.12 The HPA report (2009) was produced in response to increasing public concern about possible adverse effects of noise on health. It was prepared by an ad hoc group of experts at the request of the Department of Health and funded by the Defra. As before, this report is available on the HPA website. This report will be referred to where relevant.

4.1.13 The WHO Night Noise Guidelines for Europe (NNG) were published in October 2009. This document was presented as an extension to the WHO Guidelines for Community Noise document from 1999. The aim of the Night Noise Guidelines (2009) was to present conclusions from the WHO working group responsible for preparing guidelines to exposure to noise during sleep. These guidelines use both direct evidence concerning the effects of night noise and health, and also indirect evidence relating to the effects of noise on sleep and the relationship between sleep and health, as their basis.

4.1.14 The WHO Guidelines (1999, 2009) note that vulnerable people (e.g. people that are ill, old, depressed, foetuses, babies and young children, shift workers) may be less able to cope with the impacts of noise exposure and they may be at greater risk of harmful effects. Generally, there is little scientific research focused on these vulnerable groups. An exception to this is the research of the effects of environmental noise on children; a body of scientific literature specifically on the effects of aircraft noise on children is emerging. The limited evidence on foetal effects presented in various reviews is also summarised in this section.

4.1.15 The literature on the non-auditory health effects of environmental noise is extensive; this review does not aim to give an in-depth assessment of the nuances of the scientific work in this field, but to provide a succinct overview of the current research in this area.

4.2 Myocardial Infarction (MI) and Hypertension

4.2.1 Di Nisi *et al* (1990) investigated the cardiovascular responses to noise during wake and sleep in two groups of 40 males and females each grouped according to self reported sensitivity to noise being high or low. Subjects were exposed to common noises such as aircraft at 67 dBA, trucks at 61.9 dB, motorcycles at 52.7 dB, trains at 68.2 dB and telephones at 62 dB all L_{Aeq}, with a maximum intensity of the aircraft noise at 86 dB L_{Aeq} occurred in the morning and afternoon. Heart rate and finger-pulse responses were compared to sensitivity, gender and time of day.

4.2.2 Heart rate (HR) responses showed differences between the sensitivity groups, but not type of noise, whereas the opposite was found for finger-pulse (FP) results, with no significant difference in sensitivity but clear differences between noises.

4.2.3 Ten subjects from each group were selected and exposed to the same noises at night whilst being recorded. Both HR and FP were greater during the sleep period for both groups, compared to waking, and did not differ between gender or sensitivity. Both responses showed differences in noise types, which were based on their noise-equivalent level value.

4.2.4 The relationship between road traffic and blood pressure and heart rate in preschool children was examined during the night at children's residences, and during the day at Kindergartens (Belojevic et al, 2007). A cross-sectional study was performed on 328 preschool children ages 3-7years, who attended 10 public kindergartens in Belgrade. L_{Aeq} was measured during the night in front of the children's homes and during the day in front of the kindergartens. A home was classified as noisy if the Leq exceeded 45 dBA during the night and quiet if the L_{Aeq} was ≤ 45 dB. Noisy and quiet kindergartens were those with daily L_{Aeq} > 60 dB and ≤ 60 dB respectively. The prevalence of children with hypertensive values of blood pressure was 3.9%, with a higher prevalence in children from noisy residences (5.7%), compared to children from quiet residences (1.48%). Systolic pressure was significantly higher (5mmHg on average) among children from noisy residences, compared to children from both quiet environments. Heart rate was significantly higher (2 beats/min on average) in children from noisy residences. The authors stressed, however, that it was not known if these effects were of a temporary nature and whether they could be reversed upon cessation of the noise exposure.

4.2.5 A cross-sectional study of environmental noise and community health was conducted in neighbourhoods around Sydney Airport, with high exposure to aircraft noise and in a matched control suburb unaffected by aircraft noise (Black et al, 2007). The relationships between health-related quality of life and aircraft noise, and long-term exposure to aircraft noise and adult high blood pressure levels were examined using social surveys. Noise measurements were undertaken that lead to the development of a novel metric – the noise gap index, NGI that includes considerations of background environmental noise. The NGI was developed as an index that is easy to understand by the layperson, and that also quantifies relevant aspects of the potential impacts of aircraft noise. It was found that subjects living in high and medium background environmental noise areas were more likely to be annoyed by the same aircraft noise exposure level than subjects living in low background environmental noise areas. The research concluded that:

- Long-term aircraft noise exposure was significantly associated with chronic noise stress
- Chronic noise stress was significantly associated with prevalence of hypertension

4.2.6 Perhaps the most publicised study to examine the effects of aircraft noise on hypertension in recent years is the HYENA study (Hypertension and Exposure to Noise near Airports) (Larup et al, 2007). A total of 4861 people participated in the study, in an age range of 45-70 years old, with a minimum length of residence of five years, living near one of six major European airports (London Heathrow, Berlin Tegel, Amsterdam Schiphol, Stockholm Arlanda, Milan Malpensa and Athens Elephterios Venizelos airport). The selection process created exposure contrast to aircraft noise and road traffic noise within countries, ensuring that sufficient numbers of inhabitants in the appropriate age range had expected exposures > 60 dBA and < 50 dBA. Participants were interviewed by specially trained staff, and their blood pressure measured on three occasions; at the beginning of the interview, after five minutes' rest, and then again after a further one minute's rest and finally after the interview as a validity control. The mean of the first two readings was used to define blood pressure for the subsequent analyses.

4.2.7 **Figure 10** shows the odds ratios for hypertension in relation to aircraft noise during the day ($L_{Aeq,16h}$) and during the night (L_{night}). A rise in odds ratio with increasing exposure is indicated primarily for night-time noise, with no differences found between males and females.

4.2.8 **Figure 11** shows the odds ratios for hypertension in men and women in relation to average road traffic noise exposure ($L_{Aeq,\ 24h}$) An increase in risk for men with increasing exposure was reported, but this was not found in women.

Figure 10 Odds ratios of hypertension in relation to aircraft noise (5 dB categories). LAeq, 16h (A) and Lnight (B) were included separately in the model. Adjusted for country, age, sex, BMI, alcohol intake, education, and exercise. Error bars denote 95% confidence intervals for the categorical (5 dB) analysis. The unbroken and broken curves show the ORs and corresponding 95% CIs for the continuous analysis. Taken from Jarup et al, 2008.

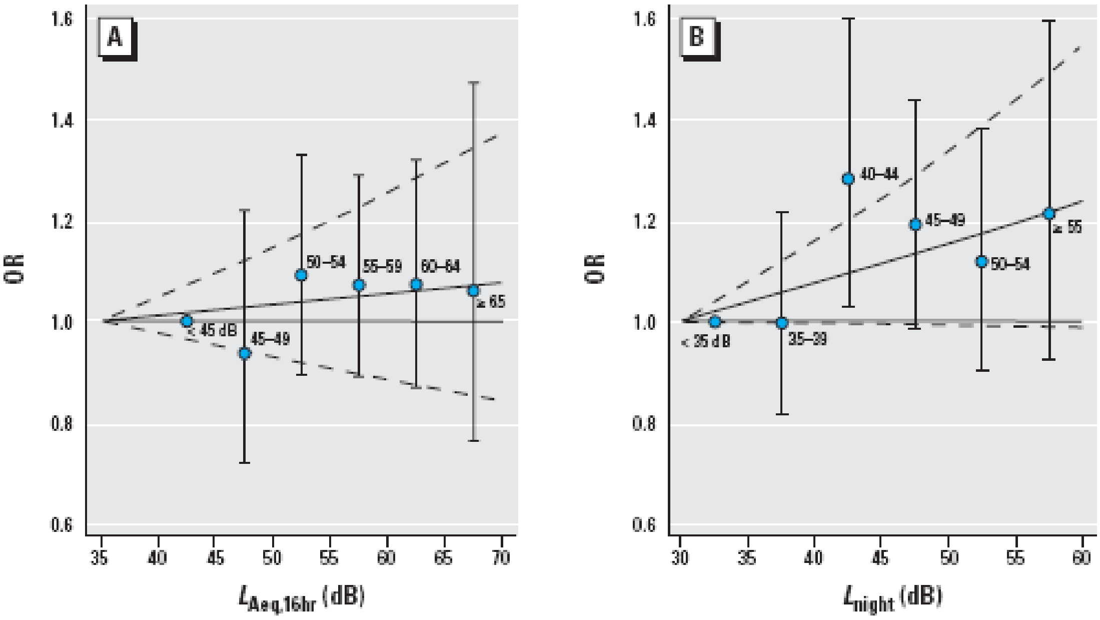
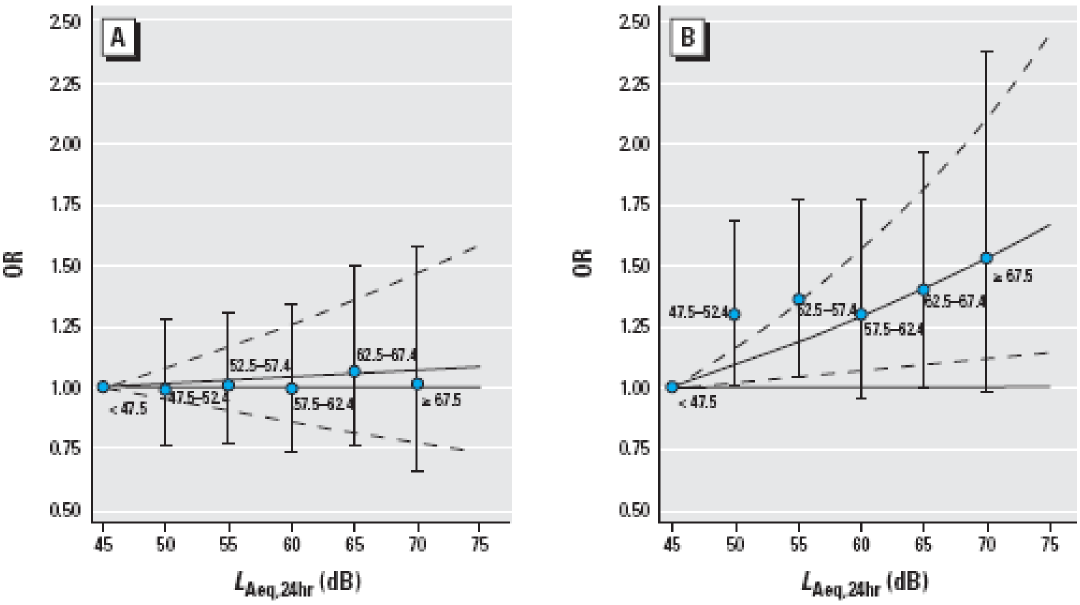


Figure 11 ORs in women (A) and men (B) in relation to road traffic noise ($L_{Aeq,\ 24h}$, 5 dB categories) separately included in the model. Adjusted for country, age, sex, BMI, education, and exercise. Error bars denote 95% confidence intervals for the categorical (5 dB) analysis. The unbroken and broken curves show the ORs and corresponding 95% CIs for the continuous analysis. Taken from Jarup et al, 2008.



4.2.9 The results from the HYENA study indicated that there were significant exposure response relationships between exposure to night-time aircraft noise exposure, daily average road traffic noise and risk of hypertension. The authors highlighted that the higher risk for night-time noise may be a consequence of less misclassification of exposure during the night (i.e. participants are more likely to be home during the night). They suggest that the higher night-time risks may also be explained by acute physiological responses induced by night-time noise events that might affect restoration during sleep. The gender difference with relation to road traffic noise was an interesting finding and one that could be explored further. Overall, the conclusions from the HYENA study were that the increased risk of hypertension in relation to aircraft and road traffic noise near airports might contribute to the burden of cardiovascular disease. The authors suggested that that preventative measures should be considered to reduce road traffic noise and night-time noise from aircraft.

4.2.10 As part of the framework of the HYENA study, the acute effects of night-time noise in relation to blood pressure were also reported in 140 subjects (Haralabidis et al, 2008). Measurements of blood pressure were taken every 15 minutes during the study night in participants' homes. Noise level equivalents for every second, every minute and for every 15-minute period in-between blood pressure measurements were calculated. Noise events were classified into four categories:

- Indoor
- Aircraft
- Road traffic
- Other outdoor

4.2.11 The results indicated that both systolic and diastolic blood pressure, as well as heart rate increased with higher noise levels during the preceding minutes, independently of the noise source. Significant increases in blood pressure was also seen when the source of the noise was taken into account. The effects of the source-specific noise were comparable for aircraft, traffic and indoor events and were similar to those of the total measured noise. The authors concluded that the absence of short-term habituation to the cardiovascular effects of noise, especially those during sleep, are likely to support a link between acute and long-term effects of noise exposure and hypertension and cardiovascular disease.

4.2.12 Greifahn *et al* (2008) analysed heart rate responses to traffic noise during sleep, and examined the effects of factors such as time of night, acoustic parameters and momentary sleep stage. Twenty-four subjects were required to sleep in the laboratory for four consecutive nights, for three consecutive weeks, with exposure to aircraft, road or rail noise in each of the weeks. One of the nights was a randomly assigned quiet night (32 dBA), and the noise exposure nights had maximum levels of 45-77 dBA. PSG and ECG were recorded throughout each of the nights, with participants being asked to sleep between 2300 and 0700. The results indicated that response patterns were mainly determined by the occurrence or absence of awakenings. When awakenings occurred, heart rate responses were monophasic and increased over more than one minute. These responses were not influenced by the acoustic parameters, with the strongest influence being the sleep stage at which the exposure occurred. The strongest response was found during REM sleep, with the weakest response occurring when subjects were in SWS.

4.2.13 When awakenings did not occur, the heart rate responses were biphasic. An initial acceleration with a maximum after four to eleven seconds was followed by a deceleration to a minimum below the baseline after 12 to 23 seconds, followed by a consecutive increase towards baseline values. In these instances, there was a significant influence of the type of noise, with railway noise causing the earliest and aircraft noise producing the latest increase in heart rate. The same pattern of response was observed as before in terms of sleep stage, with the largest change seen in REM, and the smallest in SWS.

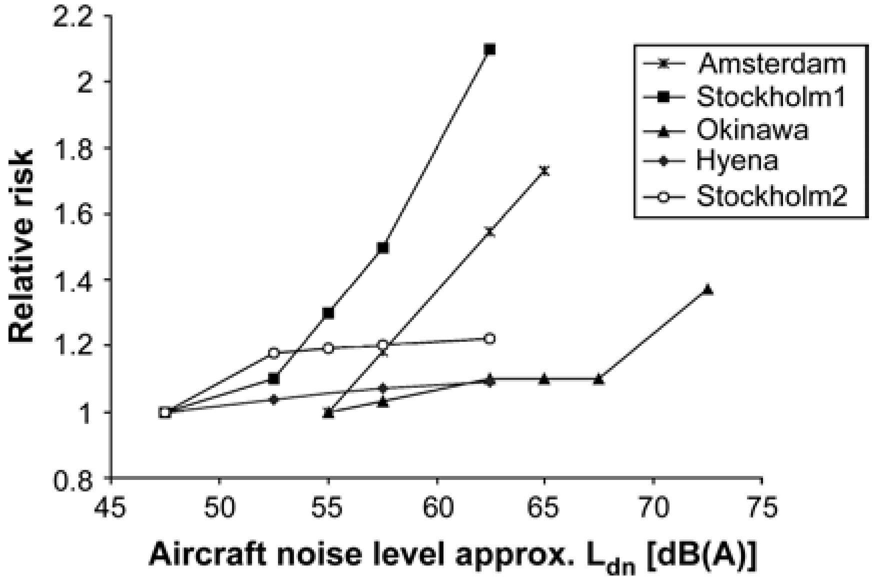
4.2.14 These responses did not decrease as a function of time throughout the night, and the authors suggest that therefore habituation is unlikely to occur. They suggest that this may be the main reason for potentially pathologic responses over time, and that these may play a significant part in promoting traffic noise induced cardiovascular disease, particularly in those responses accompanied by awakenings.

4.2.15 Basner *et al* (2008) reported data on the comparison between sleep disturbance responses measured by polysomnography, and single channel ECG with respect to aircraft noise, with the hypothesis being that cardiac activations can be used as estimates for EEG awakenings. Data from 129 subjects, 985 nights and 23855 ANEs were used. Subjects were required to sleep in a laboratory for 13 nights, with night 1 as an adaptation night, 2 as a baseline, and nights 3-11 involving ANEs with levels between 45 and 80 dB L_{Amax}. 30 different exposure patterns were used, to give a spread of values of SPL and number of ANEs across the study, and these were randomly assigned.

4.2.16 Both EEG awakenings and cardiac activations increased with increasing maximum SPLs. The two types of responses were highly correlated, with exposure-response curves for reactions induced by aircraft noise being almost identical for EEG and ECG responses. This suggests that the single channel ECG is a good estimate of EEG responses. It was therefore suggested that the ECG method might prove to be an effective way of collecting physiological data from large numbers of unsupervised participants, possibly alongside other low maintenance methods such as actigraphy in order to further validate results. The analysis of the ECG data is automatic and objective as it is analysed using an ECG algorithm, and therefore is also more reliable, faster and cheaper than PSG analysis. Basner stresses that further investigation and validation in the field is required, and that at present, polysomnography remains the gold standard for recording physiological response to nocturnal noise exposure.

4.2.17 Babisch and van Kamp (2009) evaluated the Exposure-response relationship of the association between aircraft noise and the risk of hypertension. There has been no clear association found between aircraft noise, ischemic heart disease, and myocardial infarction, possibly due to the absence of large scale quantitative studies. There is sufficient qualitative evidence, however, that aircraft noise increases the risk of hypertension in adults. The authors evaluated the literature for the WHO working group on “Aircraft Noise and Health”. With respect to the needs of a quantitative risk assessment for burden of disease calculations, the authors attempted to derive an exposure-response relationship based on a meta-analysis. An in-depth discussion of the criteria for inclusion is given in the paper, with five studies being chosen as the basis for analysis. An approximate graphical representation of the results are given in **Figure 12**, but authors caution that no conclusions regarding possible threshold value or noise level related risks (in absolute terms) can be drawn.

Figure 12 Association between aircraft noise level and the prevalence or incidence of hypertension



4.2.18 When linear trend coefficients of all the five studies are calculated and pooled afterwards ('regression approach') the pooled effect estimate of the relative risk is 1.13 (95% CI = 1.00-1.28) per 10 dBA. The authors caution that the limitations involving the pooling of studies due to methodological differences in the assessment of exposure and outcome between studies mean that the association must be viewed as preliminary. It is suggested to use Lden ≤ 50 or Lden ≤ 55 dBA as a reference category of the exposure-response relationship. The respective relative risks for subjects who live in areas where Lden is between 55 to 60 dBA and between 60 to 65 dBA would then approximate to 1.13 and 1.20, or 1.06 and 1.13, respectively.

4.2.19 A Swedish study (Rosenlund, 2001) found that the prevalence of hypertension was higher among people exposed to average noise levels of at least 55 dBA or maximum levels above 72 dBA, around Arlanda airport, Stockholm. However, the methodological approach of this study has been criticised.

4.2.20 Goto (2002) reported on a study to investigate the blood pressure levels in those living around an airport in Japan. Examination of study data from 469 women living around the airport, and exposed to varying levels of aircraft noise, found that blood pressure was not associated with aircraft noise level. In a questionnaire survey around Schiphol Airport, Franssen, (2004) found that the risks of poor self-rated health, and of medication use for cardiovascular diseases or increased blood pressure, increased with aircraft noise levels. Franssen concludes that exposure to aircraft noise may be a risk factor for cardiovascular disease.

4.2.21 It is not only the effects of aircraft noise on sleep during the night that has been studied. Carter *et al* (2002) examined the cardiovascular response to environmental noise during sleep in shift workers who were sleeping during the day in a sleep laboratory. Nine female permanent night duty nurses were exposed to noises from trucks, civilian aircraft, low altitude military aircraft and tones, presented at 55, 65 and 77 dB $L_{Amax.}$ The authors reported that heart rate was responsive to noise levels, but not the noise type. Blood pressure increased primarily to the sudden onset of sounds, and noise-induced awakening and alpha wave EEG responses were related to blood pressure increases. Any increase in heart rate was greatest when subjects were awakened by noise, or were already awake. The authors concluded that over these range of noises, heart rate responds to noise level during sleep, and blood pressure to sounds of a sudden onset. However, they recommend that due to the sensitivity of the spectral analysis of blood pressure, it should be studied in people sleeping in their own home.

4.2.22 Often, there is a discussion that sleep represents a trophotopic phase (energy storing), contrasting with an ergotropic (energy consuming) phase when we are awake (Maschke and Hecht 2004). Therefore, frequent, or long-awakening reactions endanger recovery and therefore health. Such frequent occurrences of arousal triggered by nocturnal noise can lead to a deformation of the circadian rhythm. Also, the deep SWS phases in the first part of the night are associated with a nadir of cortisol, and a maximum of growth hormone, both necessary for the physical wellbeing of the sleeper.

4.2.23 The link between hypertension and road traffic noise exposure was studied (de Kluizenaar et al, 2007). The study design was cross-sectional (n = 40,856) and participants were inhabitants of Groningen, Netherlands. Before adjustment for confounding variables, road traffic noise exposure was associated with self-reported use of antihypertensive medication in the whole sample, however following adjustment the association persisted in subjects between 45 and 55 years old, and at exposure levels of L_{den} > 55 dB. The authors suggested that exposure to high levels of road traffic noise may be associated with hypertension in subjects in this age range, and that the associations are stronger at higher noise levels.

4.2.24 Heart rate, blood pressure and noise perception in relation to aircraft noise was measured in residents around Frankfurt Airport (Aydin and Kaltenbach, 2007). Two areas were selected, in which aircraft noise was the predominant source of noise created by aircraft taking off but not landing. The responses of residents were measured over a twelve week period, with one area being exposed to air traffic noise for three quarters of the given time, and the other area only exposed for one quarter of the time. Blood pressure and heart rate was monitored in 53 subjects (aged 50-52 ± 15 years) over three months, alongside subjective perception of noise and sleep quality. Thirty one subjects lived to the west of the airport, and were exposed to a nocturnal equivalent continuous air traffic noise level of L_{Aeq} = 50 dB outside during departures from runway 25. Twenty-two subjects lived east of the airport and were exposed to L_{Aeq} = 50 dB during departures from runway 07. During opposite flight directions, aircraft noise corresponded to L_{Aeq} = 40 dB in both areas. The airport operated runway 25 for about 75% of the time, and runway 07 for 25% of the time. Average blood pressure was significantly higher in the West group with higher noise exposure. Morning systolic and diastolic blood pressure was higher in the west group. The East group exhibited a daily parallel between changes in noise and their subjective noise perception, which was not found in the west group. The authors suggested that this was a consequence of higher noise stress levels in the West group, and concluded that a nocturnal aircraft noise level of L_{Aeq} = 50 dB can have negative effects on subjective noise perception and on objective parameters of circulation.

4.2.25 A paper by Basner, Griefahn and van den Berg (2010) focuses on an Anotec Consulting study in 2003, which examined 400,000 people that were exposed to a L_{night} > 45 dB, around 53 major airports in the EU. The authors explain that this is likely to increase to 550,000 in 2015 and aimed to analyse noise-induced sleep disturbance by looking at:

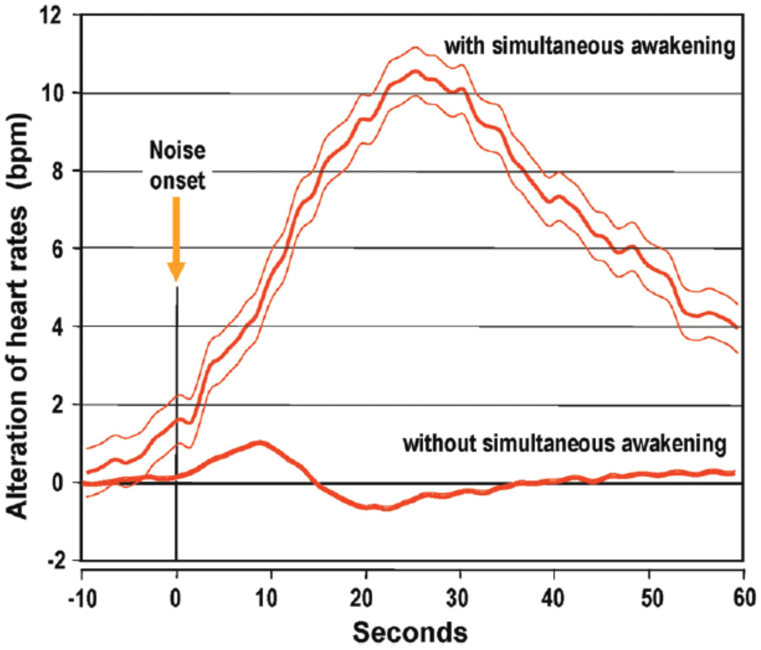
- Event-related analysis
- Whole night sleep parameters
- Dose-response relationships
- Mitigation of aircraft noise effects
- Vulnerable groups
- Research needs

4.2.26 Event –related analysis is discussed, which establishes a direct association between an ANE and the reaction of the subject, although because awakenings occur spontaneously as well as a response to aircraft noise this must be taken into account. EEG awakenings are most often used as predictor of long-term health effects because:

- Awakenings are strongest form of activation
- Specific
- Awakenings usually occur with increases in heart rate, which in turn can play a role in high blood pressure and cardiovascular disease

4.2.27 The following graph (**Figure 13**), taken from Griefahn (2006) shows the noise-induced alterations in heart rate with and without simultaneous EEG awakenings.

Figure 13: Noise induced changes in heart rate with and without EEG awakening



4.2.28 With EEG awakenings the maximum average heart rate increased by 10 b.p.m and did not reach baseline levels 60s after onset. Without EEG awakening the maximum average heart rate increased by 1 b.p.m and reached baseline levels 15 seconds after noise onset.

4.2.29 These data highlights the importance of the relationship between a noise stimulus and the autonomic cardiovascular responses should awakening as defined by changes in the EEG occur, and illustrates the need to keep additional awakenings induced by aircraft noise at night, to a minimum.

4.2.30 The analysis of whole night sleep parameters resulted in the following findings:

- Noise can result in an overall heightened state of arousal level that leads to a redistribution of time spent in different sleep stages
- An increase in wake and stage 1 sleep
- Decrease in REM and SWS
- Although overall changes are relatively small, these could be of clinical relevance in sensitive populations or chronic exposure situations in terms of short-term (e.g. daytime sleepiness) and long-term (hypertension) health effects

4.2.31 This detailed paper stresses the need for future large scale field studies on the effects of nocturnal aircraft noise on sleep. It is suggested that several groups of the population are included, such as children and chronically ill. Long- term studies are needed to investigate the future consequences of noise-induced sleep disturbance. Further recommendations include epidemiological case-control studies on the association of nocturnal aircraft noise exposure and cardiovascular disease.

4.2.32 Greiser et al (2011) published research concerning the risk increase of cardiovascular diseases and impact of aircraft noise in the Cologne-Bonn airport study. Previously, research had shown that there was an increase in the amount of cardiac medication prescribed with increasing aircraft noise exposure (2007). Aircraft, road and rail noise data were linked to hospital discharge diagnoses of 1,020,528 people living in the study area. Confounders included age, environmental noise, prevalence of social welfare recipients of residential quarters and interaction of aircraft noise with age. The results showed that as age increased, the risk of cardiovascular disease decreased. Risk is more marked in females than males. For night-time aircraft noise of 50 dB L_{night} at aged 50, the odds ratio for cardiovascular disease in men was 1.22 and in women 1.54, for myocardial infarction it was 1.18 in men and 1.54 in women, for heart failure in men 1.52 and 1.59 in women, stroke in men 1.36 and for women 1.36 also.

4.2.33 Floud et al (2011) reported on the medication use in relation to aircraft noise of populations surrounding six European airports, as part of the HYENA study. Differences were found between countries in terms of the effect of aircraft noise on antihypertensive use. For night-time aircraft noise a 10 dB increase was associated with an odds ratio of 1.34 (95% CI 1.14 to 1.57) for the UK and 1.19 (CI 1.02 to 1.38) for the Netherlands but no significant associations were found for other countries. There was also an association between aircraft noise and anxiolytic (anti-anxiety) medication, OR 1.28 (CI 1.04 to 1.57) for daytime and OR 1.27 (CI 1.01 to 1.59) for night-time. This effect was found across countries. The authors concluded that although results suggested a possible effect of aircraft noise on the use of antihypertensive medication, the effect did not hold for all countries. The data was more consistent for anxiolytics in relation to aircraft noise across countries.

4.3 Ischemic Heart Disease (IHD), including Myocardial Infarction (MI)

4.3.1 Many studies investigating the cardiovascular effects of aircraft noise examine a range of health outcomes. Some of the studies mentioned in the previous section include references to IHD, however there are studies that specifically focus on this health measure. Examples of such research are given in this section.

4.3.2 Two studies (Babisch, 1999) ‘Caerphilly & Speedwell Studies’) were undertaken to investigate the hypothesis that prolonged exposure to traffic noise at home increases the risk of IHD. The increase in risk in the noise-exposed areas was assessed relative to populations where the noise levels were less than 55 dBA. After the cohorts had been studied over a 10-year period, it was concluded that, solely on the basis of the Caerphilly and Speedwell studies it cannot be deduced that traffic noise increases the risk for IHD.

4.3.3 In 2000 Babisch published a comprehensive review of the literature on environmental noise and cardiovascular disease. Of the 10 studies reviewed by Babisch, four showed associations between traffic noise and hypertension. Of these Babisch considered that two met requirements in terms of controlling sufficiently for confounding factors. He concluded that there was little epidemiological evidence of an increased risk of hypertension in subjects exposed to traffic noise and some evidence regarding the association between transportation noise and IHD. In 2006 Babisch updated his review to incorporate new studies published since 2000. He concluded that:

4.3.4 There is no evidence from epidemiological data, that community noise increases (mean) blood pressure in the adult population. However, he notes that this lack of evidence does not discard the hypothesis that there may be a relationship between transportation noise and blood pressure but that the studies undertaken suffer from insufficient power and design difficulties.

4.3.5 With regard to aircraft noise and hypertension evidence has improved since the previous 2000 review – showing higher risks in higher exposed areas (approximate daytime average noise levels in the range 60 to 70 dBA). The findings for road traffic noise show no consistent pattern.

4.3.6 For IHD the evidence of association between community noise (review focused mainly on road traffic noise but did include some aircraft noise studies) has increased since the previous review. There is not much indication of a higher IHD risk for subjects who live in areas with daytime average noise levels of less than 60 dBA but across studies for higher noise categories, a higher IHD risk was relatively consistently found – however, statistical significance was rarely achieved.

4.3.7 The HC and ECA Reviews, and a review by Stansfeld (2000), concluded that the available evidence does not appear to convincingly demonstrate an association between aircraft noise and hypertension or IHD. However, they do conclude that the available studies provide some evidence to suggest that there may be a slight risk of IHD. All reviewers recommend that further research is needed to examine the impact of noise on cardiovascular health. The HCN Review considers that above exposures of 70 dB $L_{Aeq,16h}$ there is sufficient evidence for noise-induced IHD and hypertension.

4.3.8 In an analysis of 43 epidemiological studies (published between 1970 and 1999 for both occupational and environmental exposure) that investigated the relationship between blood pressure and/or IHD disease, van Kempen (2002) concluded that the evidence on noise exposure, blood pressure and IHD is still limited. With respect to hypertension, results were contradictory, a significant association was found for air traffic noise and hypertension but there was little evidence of an increase in blood pressure in subjects exposed to road traffic noise. For IHD, only a few studies were available and the evidence for association between noise exposure and IHD was found to be inconclusive.

4.3.9 A study (Willich, 2006, Babisch, 2005) was undertaken in Berlin to determine the association between chronic exposure to road traffic noise and the risk of cardiovascular disease (specifically myocardial infarction). The data were analysed using different approaches by two research groups, both groups conclude that chronic exposure to road traffic noise increases the risk for cardiovascular disease and that the level of risk appears to be related to gender; however, the level of risk determined varies between the two approaches.

4.3.10 The Defra report examined the effects of environmental noise and the risk of cardiovascular disease, and the main conclusion drawn was that current research suggests an increasing relative risk of myocardial infarction in people living in areas with road traffic sound levels measured outdoors above 65 dB $L_{Aeq,16h}$ day, increasing up to about 1.4 to 1.5 in areas with road traffic sound levels measured outdoors above 75 dB $L_{Aeq,16h}$ day.

4.3.11 Harding et al (2011) on behalf of the Health and Safety Laboratory published a report on the quantification of noise related hypertension and the related health effects. The aims of the study were to identify the potential health outcomes associated with hypertension, to prioritise the health outcomes and quantify the links between noise and selected hypertension associated health outcomes. The second half of the report covered a methodology to allow a monetary value to be placed on the links between hypertension and health outcomes. This half of the study will be covered in section 6 of this report.

4.3.12 The base dose-response function for noise and hypertension used by Harding comes from Babisch and van Kamp (2009) who found an odds ratio for hypertension of 1.13 per 10 dBA increase in L_{den} in the range 45 to 70 dBA. Harding goes on to note that because the prevalence of hypertension in the population is greater than ten percent, that the odds ratio must be converted into relative risk in order to quantify the effect on the population.

4.3.13 Previously, IGCB(N) and WHO have considered that there is insufficient certainty from which to quantify the health outcomes from hypertension. However, Harding et al, after extension review, found the following health outcomes from hypertension could be quantified:

<u>Cardiovascular disease</u>

4.3.14 The report concluded that there is substantial evidence for hypertension and blood pressure being an independent risk for cardiovascular disease (CVD). Many studies investigating hypertension or blood pressure as an independent causal factor for CVD have used separate analyses for stroke and IHD. It has been suggested that systolic blood pressure may be a better indicator of CVD risk than diastolic blood pressure.

<u>Stroke</u>

4.3.15 The report discusses evidence of blood pressure being linked to all types of stroke, ischaemic (resulting from a clot) and haemorrhagic (rupturing of blood vessels within the brain). Hypertension is a known risk factor for strokes.

<u>Ischaemic Heart Disease (IHD)</u>

4.3.16 There is strong evidence for a link between blood pressure and the incidence and mortality of IHD. IHD is due to the build up of plaque deposits on the artery walls and therefore leads to hardening of the arteries. When the plaque comes away from the walls, blockages can occur in the arteries which can cause a lack of oxygen (ischaemia) in the heart muscle. When the rupture of plaque on the coronary arteries occurs a clot can form, which can subsequently cause a rapid slowing or stop of blood flow and then the classic heart attack (myocardial infarction). There is evidence that lowering blood pressure can help prevent heart attacks.

Dementia

4.3.17 The report discusses the evidence linking hypertension and dementia, or cognitive decline. The evidence is less strong than for cardiovascular disease, and is complicated by the ethical issues involved in studying long-term hypertension without treatment and also because by the time dementia manifests, hypertension can decrease as a result of weight loss or metabolic changes. There have also been findings that link cognitive decline with blood pressure in subjects ages 59-71 years.

4.3.18 The report also discussed the links between hypertension and end stage kidney disease, pregnancy, eye conditions and sexual function, but it was decided that based on the strength of the evidence and impact on the population that three health outcomes would be given priority in terms of quantification of links between noise and hypertension. These were Acute Myocardial Infarction (AMI), stroke and dementia. The outcomes of the quantification process for these end points are outlined in Section 6 of this report.

4.3.19 It should be noted that this study was designed to assess the risk of noise-related hypertension on the subsequent likelihood of hypertension resulting in the above health outcomes; it is not reporting that noise itself directly causes stroke and dementia.

Stress and mental health effects

4.3.20 Various reviews on environmental noise and health have concluded as follows:

- HCN (1999): the evidence for a causal effect between noise exposure and biochemical effects is limited.
- HC (2002): the available research does not support the contention that there is a significant risk of chronic stress arising from long term exposure to outdoor daily aircraft noise levels above 65 dBA.
- ECA (2004): internationally the evidence from epidemiological studies for an impact on long term stress is limited or suggestive only.

All reviews identify the need for further research in this area.

4.3.21 However, some recent studies have identified elevated levels of stress hormones in association with noise exposure at night-time and in children exposed to aircraft noise.

4.3.22 The contractility of the stomach was examined in relation to different types of noise (Castle et al, 2007). Subjects were exposed to hospital noise, traffic noise and conversation babble and their gastric myoelectrical activity was recorded. The results indicated that loud noise altered the electrical activity in the stomach particularly in younger people under the age of 50 years.

4.3.23 Black et al (2007) suggest that although there are often instances of increased pharmaceutical drugs for hypertension and stress around airports, no studies have applied cognitive behavioural therapy (CBT) as an intervention to alleviate stress experienced by residents from long-term exposure to aircraft noise living around commercial or military airports, and this may be a valuable tool in helping to decrease the stress-inducing effects of aircraft noise.

4.3.24 The published research findings on the impact of night-time environmental noise exposure on stress hormone levels are inconsistent. Maaß (2004) reports findings of a sleep laboratory study and associated field study investigating the effects of nocturnal aircraft noise; he found no significant influence of aircraft noise on excretions of stress hormones or electrolytes.

4.3.25 Maschke (2004) has observed that average stress hormone levels may be acutely raised by traffic noise at night. At the same time, the quality of the sleep experienced by the test persons and their feeling of well-being next morning is poorer. Exposure to 16 overhead flights with maximum levels of 55 dBA produced a significant increase in the secretion of stress hormones. He also notes that the general findings in relation to noise exposure at night and stress hormone levels in overnight urine samples are inconclusive, and show individuals with increases in stress hormone levels and others with decreased values.

4.3.26 In a study by Babisch (2001) of middle aged women living in Berlin, whose bedrooms or living rooms faced streets of varying traffic volume, significant associations were found between noise exposure and the nocturnal secretion of stress hormones in urine, with regard to exposure in the bedroom (but not in the living room). This indicated a higher chronic physiological stress response in noise exposed subjects as compared to the less exposed. Babisch concludes that, the fact that noise effects were only seen with regard to exposure of the bedroom and not the living room of the subjects, suggests that particularly night-time disturbances of sleep may be associated with adverse effects of traffic noise.

4.3.27 Based on a review of recent studies on the relationship between traffic noise disturbance at night and increases in stress hormones Ising (2004) concludes that:

> "…noise exposures over time periods of years may induce, in a certain percentage of exposed persons, permanent changes of stress hormone regulation, along with possible consequences in terms of functional and organic damages."

4.3.28 In a review of the literature on environmental noise and mental health Stansfeld (2000) concluded that current evidence does seem to suggest that environmental noise exposure, especially at higher levels, is related to mental health symptoms (such as depression) and possibly raised anxiety and consumption of sedative medication, but there is little evidence of more severe health problems such as clinically definable psychiatric disorder. For example (examples taken from Stansfeld's Review):

- A questionnaire study of 1053 residents living around Kadena military airport in Japan found an association between the highest noise exposure group and higher scores of depressiveness and neurosis.
- In a British study of 7540 people exposed to road traffic noise, it was found that the noise level was weakly associated with a mental health symptoms scale.
- A study of the impact of traffic noise (undertaken in Caerphilly) found that there was no association between road traffic noise and minor psychiatric disorder. However, there was a small non-linear association of noise with increased anxiety scores.
- A Health Impact Assessment around Schiphol Airport suggested that the use of non-prescribed sleep medication or sedatives was associated with aircraft noise exposure during the late evening, but not with exposure during the night. Vitality related health complaints such as tiredness and headache were associated with

aircraft noise, whereas most other physical complaints were not.

4.3.29 Meister (2000) reports on a questionnaire based survey (among 2001 respondents living in Minnesota, USA) to assess the impact of commercial aircraft noise on human health. Four of the neighbourhoods in the survey were exposed to aircraft noise and two non-exposed control communities were also included. Meister found:

- All general health measures were significantly worse for the neighbourhoods exposed to aircraft noise than for the controls – the greater the noise levels the worse the health measures were.
- Mental health scores in neighbourhoods exposed to noise were lower than the scores in the control neighbourhoods (higher score implies more positive health status).
- A sense of vitality reduced among those exposed to aircraft noise compared with those not exposed.
- Stress levels were higher among those exposed to aircraft noise; as stress increased mental health and a sense of vitality decreased.

4.3.30 Stansfeld (2000) reports that studies from the 1970s and 1980s found that a high percentage of people reported headaches, restless nights and being tense and edgy in high noise areas. However, an explicit link between aircraft noise and symptoms in these studies raises the possibility of a bias towards over-reporting, due to personal attitudes towards aircraft noise. A study around three Swiss airports, which did not mention that the study was related to aircraft noise, did not find any association between the level of aircraft noise exposure and symptoms.

4.3.31 Evidence that exposure to aircraft noise is associated with higher psychiatric admission rates is mixed. Early studies (in the 1970s) around Heathrow and Los Angeles Airports found weak associations between the level of aircraft noise and psychiatric hospital admissions in the general population. These studies have been criticised on methodological grounds and further comprehensive studies have found, at most, a moderating rather than a causal role for noise on hospital admission rates. However, Kryter (1990) found an association between aircraft noise and psychiatric hospital admission rates in a re-analysis of data accepting admissions from around Heathrow Airport.

4.3.32 Researchers suggest that it may be that certain groups are more vulnerable to noise in the mental health context – particularly, children, the elderly and people with pre-existing illness, especially depression.

4.3.33 The Defra and HPA reports did not conclude that there is sufficient evidence for a reliable dose-response relationship between environmental noise and psychological health, and therefore suggest that this is an area that requires further investigation before any conclusions can be drawn.

4.3.34 Catecholamines are chemical compounds that function as neurotransmitters or hormones, and can be measured in urine or blood. Examples of catecholamines include noradrenaline and dopamine, which act as neuromodulators in the central nervous system, and as hormones in the blood circulation.

4.3.35 Catecholamine levels can be measured as an indicator of stress, which can be induced from psychological reactions or environmental stressors such as increased sound levels, intense light, or low blood sugar levels. They cause general physiological changes that prepare the body for physical activity (fight or flight), and typical effects are increases in heart rate, blood pressure, blood glucose levels, and a general reaction of the sympathetic nervous system.

4.3.36 Carter *et al* (1994) studied catecholamines in urine, cardiac arrhythmia and arousals in sleep in response to environmental noise. Nine subjects who were already documented with cardiac arrhythmia over 4 nights were investigated in a sleep laboratory. Cardiac arrhythmia (CA) has prognostic significance in people with heart disease, and raised serum catecholamines may be related to increased blood pressure and risk of heart disease. CA is common in the adult population and the causes behind arrhythmic events such as ventricular premature contractions (VPCs) are not well understood.

4.3.37 Research suggests that heart rate is responsive to environmental noise events during sleep, the response consisting of an increase followed by a decrease. Concentrations of circulating catecholamines normally reach their nadir during sleeping hours. Because noise affects heart rate during sleep, it is conceivable that serum catecholamine levels are also increased by noise-induced arousal during sleep.

4.3.38 EEG and ECG were recorded throughout each night, with the first night used for familiarisation, then two counterbalanced nights of truck or aircraft noise and one quiet night. Sleep stage and noise were related to the probability of an arousal (in this case an alpha wave response), but there was no interaction between the two factors. The probability of an alpha wave response decreased from stages 1-4 and in REM was similar to in stage 2. Alpha wave latency was found to be shorter in noise than in quiet intervals. Noise and sleep stage at interval (noisy or quiet) onset were related to the number of sleep stage changes during the interval, with reliably more sleep stage changes in noisy than in quiet intervals. Four subjects showed frequent VPCs during the experiment, and were significantly related to sleep stage but not to noise events. The excretion of urinary catecholamines did not differ between noise and quiet nights.

4.3.39 Cortisol is also an important hormone that is associated with stress, and is released by the adrenal glands. Concentrations are typically highest first thing in the morning, on waking, and lowest during sleep. Spreng (2002) assessed cortical excitations, and cortisol excretion in relation to an estimation of tolerable nightly over-flights.

4.3.40 Noise induces cortisol excretion even below the awakening threshold. Repeated noise events such as over-flights during night time leads to an accumulation of the cortisol concentration in the blood, due to its time constant of exponential decrease being about 10 to 50 times larger than for adrenaline and noradrenaline. For example the time course for the metabolisation of cortisol is 64 minutes, compared to adrenaline seconds to 3 minutes, and noradrenaline 7 to 12 minutes.

4.3.41 An attempt was made to calculate cortisol accumulation using an initial value of noise induced small cortisol increase at the nightly threshold of beginning vegetative overreaction around 53 dBA. The range of minimal and maximal normal cortisol values were used as a borderline and the relation between maximum sound pressure level and cortical excitation was taken into account and a formula developed to estimate tolerable events during night-time periods. An example of the results over 8hrs in the night was values of 11 events with 5 dBA indoor maximum level, or 5 events with 75 dBA indoor maximum level respectively.

4.3.42 Stress hormones also represent a link between noise and health impairment. The average concentration may be raised by traffic noise at night, with simultaneous deleterious effects on sleep quality and well-being the following morning.

4.3.43 Persson Waye *et al* (2004) studied the cortisol response and subjective sleep disturbance following low-frequency noise, in a counterbalanced design with half of the subjects exposed to a sound pressure level of 40 dBA on their fourth night in the sleep laboratory, with a comparative reference night on the fifth night, and the opposite for the other half. Subjective sleep disturbances were recorded by questionnaires and cortisol response upon awakening was measured in saliva.

4.3.44 Subjects were more tired and less socially orientated in the morning after nights with low-frequency noise, and mood was negatively affected also in the evening after nights with low-frequency noise. There was no effect of noise condition on cortisol response, but there were effects of group and weekday, suggesting that more work needs to be done before cortisol response can accurately be used as an indicator of noise-disturbed sleep.

4.3.45 The WHO NNG (2009) concludes that evidence does suggest that environmental noise exposure at higher levels is related to mental health symptoms and possibly raised anxiety, but there is little evidence that it has more serious effects. There is not strong evidence for the association between noise exposure and mental ill health, except perhaps above 70 dB L_{Aeq}. The document highlights that as most studies have examined the effects of daytime noise on mental health, it cannot be ruled out that night-time noise may have effects on mental health at lower levels than daytime noise.

4.4 Next day effects

4.4.1 The term ‘next day effects’ refers to the possible outcomes resulting from aircraft noise exposure that can be observed at a later stage. Generally this refers to cognitive performance and sleepiness or fatigue felt the following day.

4.4.2 Schapkin et al (2006) report that the scientific literature on whether noise-induced sleep disturbance affects the next day performance of adults is mixed. He notes that the scientific literature suggest that disturbed sleep affects performance in complex tasks, but that performance in simple psychomotor tasks can probably be prevented by individuals exerting additional effort. Schapkin investigated the impairment of neuronal mechanisms underlying performance after sleep disturbance by measuring event-related brain potentials (ERPs) – this is a new approach to investigating the impact of night-time noise. His results suggested that physiological costs to maintain performance are increased after noisy nights and that ERPs may be more sensitive indicators of moderate sleep disturbances caused by noise than performance measures.

4.4.3 The WHO Guidelines report that studies of both laboratory subjects and workers exposed to occupational noise, have found that noise adversely affects cognitive task performance. Such studies have shown that although noise induced arousal may produce better performance in simple tasks in the short term, cognitive performance substantially deteriorates for more complex tasks. Reading, attention, problem solving and memorisation are among the cognitive effects most strongly affected by noise.

4.4.4 There have been a number of field studies of school children, which have observed that noise impairs their cognitive performance, however, according to the WHO Guidelines there is no published research on whether environmental noise at home impairs cognitive performance in adults.

4.4.5 In agreement with the WHO Guidelines, other reviews report that there is good evidence from laboratory studies that noise exposure impairs performance in adults. The literature search and reviews considered have not identified any new research published since the WHO Guidelines, which contributes significantly to the understanding of the impact of aircraft noise on the performance in adults. However, reference has been found7 to a paper published in 1986, which compared the self-reports of everyday errors (failures of attention, memory and action) by subjects living in an area of West London exposed to a high level of aircraft noise with those in a similar group who lived in an area with low level of aircraft noise. The high-aircraft noise group reported a higher frequency of everyday errors and so did noise-sensitive subjects. According to Stansfeld (2000), concern has been expressed that there may be some confounding by neuroticism in these findings, and studies of the effects of noise on cognitive tasks do suggest that neuroticism and anxiety are important in determining individual differences in response to noise.

4.4.6 Basner (2008) published a paper on the effects of nocturnal aircraft noise exposure and daytime sleepiness. The purpose of the study was to objectively assess daytime sleepiness following aircraft exposure at night, using rhythmic changes in pupil diameter that are regulated by the autonomic nervous system. These changes are referred to as fatigue waves, and the measurement is given as the Pupillary Unrest Index (PUI), which is high in sleepy subjects. The results showed that nocturnal aircraft noise resulted in increased objective daytime sleepiness. Sleepiness levels increased significantly with an increase in the number of aircraft noise events ($p = 0.021$), maximum sound pressure levels ($p = 0.028$) and also with an increase in L_{Aeq} ($p = 0.013$). These levels were not sufficiently high to reach pathological levels, as observed in a study on obstructive sleep apnoea patients. Basner discussed, however, the importance of this finding in terms of objective measurements of sleepiness, and the need to investigate such objective methodology in the field also.

4.4.7 The HCN Review concludes that the evidence for causal relationship between environmental noise and decreased general performance is limited.

4.5 Children

4.5.1 Children are generally considered to be a vulnerable group, that may be less able to cope with the impacts of noise exposure and they may be at greater risk of harmful effects. In a review of the non-auditory effects of noise on health, Stansfeld (2003) explains that:

> “It is likely that children represent a group which is particularly vulnerable to the non-auditory effects of noise. They have less cognitive capacity to understand and anticipate stressors and lack well-developed coping strategies. Moreover, in view of the fact that children are still developing both physically and cognitively, there is a possible risk that exposure to an environmental stressor such as noise may have irreversible negative consequences for this group.”

4.5.2 Stansfeld (2000) also notes that some children in the population may be more vulnerable to noise effects than others. He concludes that there is limited evidence that children who have lower aptitude or other difficulties, such as learning difficulties and cerebral palsy, may be more vulnerable to harmful effects of noise on cognitive performance.

4.5.3 The WHO Guidelines provide a brief overview of the effects of environmental noise on children. They conclude that chronic exposure to aircraft noise during early childhood appears to impair reading acquisition and reduces motivational capabilities (this is based on the studies of Los Angeles and Munich Airports – see below). It is also noted that of recent concern are the concomitant psychophysiological changes (blood pressure and stress hormone levels). The WHO Guidelines consider that the evidence on noise pollution and health is strong enough to warrant monitoring programmes at schools, and that schools should not be located near major noise sources, such as airports.

4.5.4 During and since the late 1990s there has been a significant amount of research published investigating the effects of aircraft noise on children (particularly focusing on cognitive effects). Substantial studies have been undertaken around European airports:

- The Munich Airport Study (Hygge, 1998) took advantage of a natural experiment created by the closing of an existing airport and the opening of a new airport. Before the change over of airports, children at both sites were recruited into experimental and control groups. One set of data were collected prior to the change over of the airports, the second set a year later and a third set two years later. The children were assessed on physiological, perceptual, cognitive, motivational and quality of life measures.
- The West London Schools Study (WLSS – Stansfeld, 2000) a cross-sectional study which was carried out in schools in the area surrounding Heathrow Airport, to determine the association of aircraft noise exposure with cognitive performance. A total of 236 children from 20 schools took part in the study, 10 high noise schools and 10 control low noise schools.
- The Schools Environment and Health Study (SEH) – Haines (2001) - a study around Heathrow airport to compare the school performance and health of children attending four schools in a high aircraft noise area, with those of children from four matched control schools in a low aircraft noise area.
- The RANCH study (Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health; Effect Relationships and Combined Effects) – Stansfeld (2005) – a cross-sectional study that enrolled a total of 2,844 children from 89 schools around Schiphol (Netherlands), Heathrow and Barajas (Spain) Airports. This Study is the largest known epidemiological study undertaken of exposure and children's cognition and health.

4.5.5 A body of research available from a study undertaken around Los Angeles Airport by Cohen et al (1980, 1981) published in the early 1980s is also widely cited in the scientific literature. In the Los Angeles Study children in four schools exposed to high levels of noise were matched with children in three low noise schools, a first wave of measurements were followed up a year later.

4.5.6 The findings of these key studies are summarised below, along with pertinent findings from other recently published studies.

<u>Cognition in children</u>

4.5.7 Across the literature the evidence for the effects of noise exposure on child health is strongest for cognitive effects; however the effects of noise have not been found uniformly across all cognitive functions. Stansfeld (2003) summarises (this summary includes amongst others the findings of the Munich, Heathrow and Los Angeles studies described above) the effects that have been found for children exposed to high levels of environmental noise as:

- Deficits in sustained attention and visual attention.
- Difficulties in concentrating (based on teachers' reports).
- Poorer auditory discrimination and speech perception.
- Poorer memory requiring high processing demands.
- Poorer reading ability and school performance on national standardised tests.

4.5.8 More recent substantive findings on cognitive performance come from the RANCH Study. This study found that exposure to chronic aircraft noise could impair cognitive development in children, specifically reading comprehension. The results indicated a linear exposure-effect association between exposure to aircraft noise and impaired reading comprehension and recognition memory in children. The study found that aircraft noise exposure was not associated with recall, impairment in working memory, prospective memory or sustained attention. For road traffic noise the study found no association with reading comprehension, recognition, working memory, prospective memory or sustained attention and that exposure to road traffic noise improved recall; the RANCH team could find no definitive explanation for this latter finding. Stansfeld suggests that aircraft noise, because of its intensity, the location of the source and its variability and unpredictability is likely to have a greater effect on children's reading than road traffic noise, which might be of a more constant intensity.

4.5.9 Shield (2003) compared external noise levels at over 50 London schools (schools were not in areas exposed predominantly to aircraft noise) with the schools' scores in standardised assessment tests (SATs) of children aged 7 to 11. She found significant relationships between external noise levels and SATs scores, with environmental noise having a detrimental effect upon children's performance; the relationship being stronger for older children. A similar study was carried out at schools located around Heathrow airport, in this study no obvious strong consistent relationship was found between noise and SATs scores, although the results suggest that aircraft noise may have a negative effect upon SATs scores for reading.

4.5.10 The HCN Review considers the findings of the Munich, WLSS and Los Angeles studies and concludes that there is sufficient evidence for a causal relationship between aircraft noise and the performance of children in schools.

4.5.11 Stansfeld et al (2010) examined the effect of night-time aircraft noise exposure on the cognitive performance of children. This analysis was an extension of the RANCH study, and the Munich study in which 330 children were assessed on their cognitive performance in three waves, each a year apart, before and after the switch over of airports. Aircraft noise exposure and self- reported sleep quality measures were analysed across airports to examine whether changes in night-time noise exposure had any impact on reported sleep quality, and if this was then reflected in the pattern of change in cognitive performance. In the Munich study analysis of sleep quality questions showed no evidence of interactions between airport, noise and measurement wave, which suggests that poor sleep quality does not mediate the association between noise exposure and cognition. In the RANCH study, there was no evidence to suggest that night noise had any additional effect to daytime noise exposure. The authors explain that this investigation utilised secondary data and therefore was not specifically designed to investigate night time aircraft noise exposure on cognitive performance in children, but the results from both studies suggest that night time aircraft nose exposure does not appear to add any further deleterious effect to the cognitive performance decrement induced by daytime noise alone. They recommend that future research should be focussed around the school, for the protection of children against the effects of aircraft noise exposure on performance.

4.5.12 It is important to note that studies on children are mostly designed to focus on daytime noise exposure during learning; therefore there is limited or no information on night time specific effects. Children are included as part of the vulnerable groups, however, and therefore should be given due consideration in this way.

4.6 Health Effects: Conclusions

Hypertension, Ischemic Heart Disease and Myocardial Infarction

4.6.1 In terms of cardiovascular impact there are mixed conclusions from the various reviews and papers on the evidence for effects. Some reviewers consider that there is sufficient evidence, others that the evidence does not convincingly demonstrate an association. Based on existing evidence, it is possible that exposure to aircraft noise may be a risk factor for cardiovascular disease and all would agree that further research is needed to examine the impact of noise on cardiovascular health. For Myocardial Infarction, the WHO Environmental Burdon of Disease report suggests that night time effects may be of the same magnitude as day time effects, and therefore proposes an Odds Ratio of 1.1 for 60-65 dBA L_{night} and an Odds Ratio of 1.2 for 65-70 dBA L_{night}.

Stress and Mental Health

4.6.2 Reviewers generally consider that the evidence for mental health effects is inconclusive or limited. There seems to be a trend emerging of some evidence for mental health symptoms (eg depression, anxiety) but not of more severe health problems such as clinically defined psychiatric disorder.

4.6.3 The scientific literature generally finds that the evidence for long term impact on stress hormone levels is inconclusive or limited.

Next day effects (adults)

4.6.4 There is a lack of data on the impact of environmental noise on the performance of adults and no firm conclusions can be drawn. Across the scientific literature it is agreed that above a certain threshold, environmental noise can cause awakening, and at levels significantly lower, it can also induce sleep stage changes. The threshold level above which effects are found remains a controversial point. There also seems to be general consensus that environmental noise can affect subjective sleep quality, mood the next day and has an acute impact on heart rate. However, as yet, there appears to be no strong/consistent scientific evidence of chronic objective effects (e.g. on stress hormone levels or immune system) or performance the next day.

Noise and Children

4.6.5 There is a growing body of literature on the impact of aircraft noise on children's health. Across the literature the evidence for the effects of noise exposure on child health is strongest for cognitive effects (particularly reading). Some studies have found that chronically noise exposed children have raised levels of stress, increased blood pressure and mental health effects; however there is still insufficient data to provide unequivocal evidence of such effects

5 Noise Levels at which Health Effects Occur

5.1.1 The WHO NNG (2009) included tables on the observed effect thresholds of noise. The threshold levels for sufficient and limited evidence were presented.

5.1.2 Sufficient evidence is defined as: A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could reasonably be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.

5.1.3 Limited evidence is defined as: A relation between the noise and the health effect has not been observed directly, but there is available evidence of good quality supporting the causal association. Indirect evidence is often abundant, linking noise exposure to an intermediate effect of physiological changes, which lead to the adverse health effect.

5.1.4 **Table 2** summarises the sufficient evidence for exposure to night noise and health effects as given in the WHO NNG (2009).

Table 2 Summary of effects and threshold levels for effects where sufficient evidence is available (taken from WHO NNG, 2009)

	Effect	Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	*	*
	EEG awakening	LAmax,inside	35
	Motility, onset of motility	LAmax,inside	32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	LAmax,inside	35
Sleep quality	Waking up in the night and/or too early in the morning	LAmax,inside	42
	Prolongation of the sleep inception period, difficulty getting to sleep	*	*
	Sleep fragmentation, reduced sleeping time	*	*
	Increased average motility when sleeping	Lnight, outside	42
Well-being	Self-reported sleep disturbance	Lnight, outside	42
	Use of somnifacient drugs and sedatives	Lnight, outside	40
Medical conditions	Environmental insomnia	Lnight, outside	42

* Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.

5.1.5 **Table 3** summarises the limited evidence for which there may be a health effect due to night noise.

Table 3 Summary of effects and threshold levels for effects where limited evidence is available (taken from WHO NNG, 2009)

	Effect	Indicator	Threshold, dB
Biological effects	Changes in (stress) hormone levels	*	*
Well being	Drowsiness/tiredness during the day/evening	*	*
	Increased daytime irritability	*	*
	Impaired social contacts	*	*
	Complaints	Lnight, outside	35
	Impaired cognitive performance	*	*
Medical conditions	Insomnia	*	*
	Hypertension	Lnight, outside	50
	Obesity	*	*
	Depression (in women)	*	*
	Myocardial infarction	Lnight, outside	50
	Reduction in life expectancy	*	*
	Psychic disorders	Lnight, outside	60
	(Occupational) accidents	*	*

* Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.

Griefahn and Scheuch Evaluation Criteria

5.1.6 Based on an extensive review of the literature Griefahn and Scheuch (2004) suggest 'evaluation criteria' specifically for aircraft noise exposure to protect those living in the vicinity of civil airports. The purpose of these criteria is to provide guidance on the noise levels at which control measures need to be introduced, to protect communities around airports from the potential adverse health effects of noise. Griefahn and Scheuch propose a three tier hierarchy of criteria:

- Critical limits – above these levels there is a risk of health effects and such levels should only be tolerated as an exception for a limited time. Above these levels noise it is imperative that noise control measures should be introduced.
- Protection Guides – Exposure below these levels should not induce adverse health effects in the average person, although sensitive groups may still be affected. These are the 'central assessment values' above which action should be taken to reduce noise exposure.

- Threshold Values – inform about measurable physiological and psychological reactions to noise exposure where long term adverse health effects are not expected. To increase quality of life these values constitute a long term goal.

5.1.7 Griefahn and Scheuch's proposed Critical Limits, Protection Guides and Threshold Values for sleep disturbance, annoyance and cardiovascular disease are shown in **Table 4**. It can be seen that the proposed Threshold Values for annoyance and sleep disturbance are in alignment with the WHO threshold guideline levels. Griefahn notes that although the WHO Guideline Values and proposed Threshold Values provide a long-term goal, achieving them around airports is currently practically impossible without complete cessation of aircraft movements. The Protection Guides and Critical Limits provide more practical 'tolerable limits' for the avoidance of adverse health effects in those living in the communities around civil airports.

Table 4 Griefahn and Scheuch's proposed Critical Limits, Protection Guides and Threshold Values for Sleep Disturbance, Annoyance and Cardiovascular Disease

Effect	Evaluation Criteria	Measure	Value	Indoor/ Outdoor
Sleep Disturbance*	Critical Limit	dB $L_{Amax\ 22\text{-}06\ hour}$	6 events at 60 dBA	Indoor
	Critical Limit	$L_{Aeq\ 22\text{-}06\ hour}$	40	Indoor
	Protection Guide	dB $L_{Amax\ 22\text{-}06\ hour}$	13 events at 53 dBA	Indoor
	Protection Guide	dB $L_{Amax\ 22\text{-}01\ hour}$	8 events at 56 dBA	Indoor
	Protection Guide	dB $L_{Amax\ 01\text{-}06\ hour}$	5 events at 53 dBA	Indoor
	Protection Guide	dB $L_{Aeq\ 22\text{–}06\ hour}$	35	Indoor
	Protection Guide	dB $L_{Aeq\ 22\text{-}01\ hour}$	35	Indoor
	Protection Guide	dB $L_{Aeq\ 01\text{-}06\ hour}$	32	Indoor
	Threshold Value	dB $L_{Amax\ 22\text{-}06\ hour}$	23 events at 40 dBA	Indoor
	Threshold Value	dB $L_{Aeq\ 22\text{-}06\ hour}$	30	Indoor
High Annoyance**	Critical Limit	dB $L_{Aeq\ 06\text{-}22\ hour}$	65	Outdoor
	Protection Guide	dB $L_{Aeq\ 06\text{-}22\ hour}$	62	Outdoor
	Threshold Value	dB $L_{Aeq\ 06\text{-}22\ hour}$	55	Outdoor
Chronic Disease **	Critical Limit	dB $L_{Amax\ 06\text{-}22\ hour}$	19 events at 99 dBA	Outdoor
	Critical Limit	dB $L_{Aeq\ 06\text{-}22\ hour}$	70	Outdoor
	Protection Guide	dB $L_{Amax\ 06\text{-}22\ hour}$	25 events at 90 dBA	Outdoor
	Protection Guide	dB $L_{Aeq\ 06\text{-}22\ hour}$	65	Outdoor

* Griefahn and Scheuch suggest that if it is not possible to have no aircraft movements during the night, then concentrating air traffic to the first part of the night is preferable, as people are less sensitive to noise during the 2200 to 0100 hours time period and disturbances during the early part of the night can be compensated for in the following quieter period. They therefore propose different Protection Guide levels for the earlier and later part of the night as shown above.

** Griefahn and Scheuch found that the data were not strong enough to establish maximum level (L_{Amax}) evaluation criteria for annoyance or Threshold Values for chronic disease.

5.1.8 The WHO NNG (2009) concluded that below 30 dB $L_{night,outside}$, no effects on sleep are observed except for a slight increase in the frequency of body movements during sleep due to night noise. It was concluded that there is not sufficient evidence that the biological effects observed at the level below 40 dB $L_{night,outside}$ are harmful to health. The relationship between night noise exposure and health effects as summarised in the WHO NNG (2009) are presented in **Table 5**.

Table 5 Effects of different levels of night noise on the population's health (taken from the WHO NNG, 2009)

Average night noise level over a year $L_{night,\ outside}$	**Health effects observed in the population**
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, and arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,\ outside}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

5.1.9 Table 5 highlights WHO's view that above 55 dB L_{night} noise is a significant concern to public health. As a result it has set an interim target of **55 dB** $L_{night,outside}$. For the longer term it recommends that night noise exposure should be reduced below 40 dB $L_{night,outside}$. It is explained that the interim target is recommended in the situations where the achievement of the NNG is not feasible in the short-term for various reasons. The interim target is not a health-based limit value by itself and vulnerable groups cannot be protected at this level.

5.1.10 In terms of END thresholds, the WHO Night Noise guidelines give clear advice that from the health point of view the calculations of night time burden should start at 40 dB L_{night} and that action planning should at least contain actions to bring down the noise level to below 55 dB L_{night}. The EEA report suggests that lowering the actual threshold of L_{night} = 50 dB to L_{night} = 40 dB would give a better understanding of the magnitude of the problem, and consequently a better allocation of efforts.

5.2 Conclusion

5.2.1 Whilst agreement upon threshold noise levels that assure effective protection of the health of the population from night-time aircraft noise remains controversial, the evidence highlighted in sections three and four of this report illustrates the growing issue of night noise and health and in particular, the need to reduce the numbers of people exposed to levels above 55 dB $L_{night,outside}$ in order to protect public health.

6 Economic cost of sleep disturbance

6.1 Introduction

6.1.1 For the purpose of future policy surrounding night flights within the UK, it is important to assess the both the economic benefits in terms of revenue, employment etc against the health dis-benefits, or costs to the population affected by aircraft noise at night. The following reports mentioned summarise the methodology that has previously been used to calculate such cost-benefits, and the resulting issues that arise.

6.2 Defra and HPA reports

6.2.1 Two papers have recently been published in this area; the first was commissioned by the Department for Environment, Food and Rural Affairs (Defra) on behalf of their Interdepartmental Group on Cost and Benefit (IGCB) into an estimation of the dose-response relationship between noise exposure and health effects; the second was a Health Protection Agency (HPA) report entitled Environmental noise and health in the UK. Both reports were published in 2009.

6.2.2 The aims of the Defra report were:

- To identify a comprehensive list of potential adverse health impacts from noise and review the current state of evidence for each of the impacts;
- Where a robust evidence base exists, to recommend quantitative links (dose-response functions) for the impacts of noise on health which could be applied in the UK;
- Identify any emerging adverse health impacts that should be kept under review for future consideration in evaluation; and
- Identify any structural challenges to developing and maintaining strong quantitative links between noise and health outcomes.

6.2.3 In terms of night noise, the Defra report concluded that no single dose-response relationship is recommended for sleep disturbance and noise as a monetary valuation method and that further research into acute, transient and long-term effects are required, however the report did also include the findings relating to daytime noise:

- Strong empirical evidence was identified linking noise to acute myocardial infarction (AMI) (heart attacks) and other cardiovascular illnesses.
- Some evidence was found between noise and other health effects, including annoyance, mental health, hypertension (high blood pressure), sleep disturbance, cognitive development in children and hearing impairment. However, evidence around the monetary valuation of these impacts found in these studies (e.g.

amenity) was not judged to be sufficiently robust to be directly used to monetise noise impacts.

- Structural barriers were suggested to explain why consensus around a single dose-response function for any of these of noise impacts based on health effects may be delayed or prevented.
- The review has also highlighted a number of non-health impacts that may arise from noise. For example, sleep disturbance/loss caused by excessive noise may have negative impacts on both productivity and amenity.

6.2.4 The HPA report included the following:

- Discussions about difficulties in dose-response curves for annoyance and aircraft noise e.g. Scatter and changes in annoyance reactions.
- No reliable relationship between environmental noise and psychological health was found.
- The difficulty with sleep research due to habituation and issues with lab versus field studies was highlighted.
- Recommended an advisory group is set up for future research needs.

6.3 European Environment Agency Report – Good Practice Guide on Noise Exposure and Potential Health Effects

6.3.1 The Expert Panel on Noise (EPoN), which is a working group that supports the European Environment Agency and European Commission with the implementation and development of an effective noise policy for Europe, produced this report in 2010.

6.3.2 The group aims to build upon tasks delivered by previous working groups, particularly regarding Directive 2002/49/EC relating to the assessment and management of environmental noise. This good practice guide is intended to assist policymakers, competent authorities and any other interested parties in understanding and fulfilling the requirements of the directive by making recommendations on linking action planning to recent evidence relating to the health impacts of environmental noise and, among others, the WHO Night Noise Guidelines for Europe.

6.3.3 With respect to risk assessment of noise impact, the document refers to the assessment of *attributive fraction* which describes the reduction in disease incidence that would be observed if the population were entirely unexposed, compared with its current (actual) exposure pattern.

$$AF = \left\{ \sum \left(P_i . RR_i \right) - 1 \right\} \Big/ \sum \left(P_i . RR_i \right)$$

where: AF = Attributive Fraction
P_i = Proportion of the population in exposure category i
RR_i = relative risk at exposure category i compared to the reference level.

6.3.4 An example is presented using the German population exposed to road noise, but it would be possible to do the same with aircraft noise to obtain the percentage number of people exposed and the relative risk of Myocardial Infarction (or other variables) due to aircraft noise.

6.3.5 The paper also discusses the quality targets that should be aimed for within the member states and shows a comparison of the Lden planning values for residential areas between the states. It is noted that although most of the limits are close to the WHO noise and health recommendation of 50/55 $L_{Aeq,16h}$, some are substantially higher. For the night-time levels, the averages are L_{night} = 50 dB for railway road noise, 46 dB for aircraft noise and 42 dB for industry.

6.4 WHO Burden of Disease due to Environmental Noise

6.4.1 In this report DALYs are expressed as:

$$DALY = YLL + YLD$$

6.4.2 Where YLL is the number of years of life lost and YLD is the number of years lived with disability.

6.4.3 The Environmental Burden of Disease (EBD) of each end-point was estimated using the following information and data:

- the distribution of environmental noise exposure within the population;
- the exposure–response relationships for the particular health end-point;
- the population-attributable fraction due to environmental noise exposure;
- a population-based estimate of the incidence or prevalence of the health end-point from surveys or routinely reported statistics; and
- the value of DW for each health end-point.

6.4.4 The percentage of "highly sleep disturbed" persons (HSD) due to aircraft noise exposure as a function L_{night} was calculated with the equation:

$$HSD(\%) = 18.147 - 0.956 \times L_{night} \times 0.01482 \times L_{night}^{2}$$

6.4.5 In this case the measure for HSD was based on a self-reported scale of 1-100 of sleep disturbance. A similar approach as taken for annoyance was adopted, with cut off values for HSD chosen as 50 and 72 respectively in order to determine the percentage of people highly sleep-disturbed by transportation noise.

6.4.6 WHO proposed two approaches to calculating EBD from the HSD data:

<u>Exposure based assessment:</u> The exposure-based approach estimates the prevalence of high sleep disturbance (reporting 72 or higher on a 100-point scale) due to noise by combining the exposure data with the exposure–response relationships for high sleep disturbance. One year of night-time exposure to road traffic noise is proposed as the duration causing high sleep disturbance, since people with a bedroom exposed to a road with a high level of night traffic are subject to more or less stationary noise levels at night. Therefore, it can be assumed that their sleep disturbance exists all year round.

DALYs for sleep disturbance were calculated using the road traffic noise exposure distribution in L_{night} as assessed in the Netherlands in 2000, the total population of the Netherlands in 2000 (15 864 000), the exposure–response relationships presented above for sleep disturbance due to road traffic noise (using the expected percentage of highly sleep-disturbed people at the midpoint of the category as a function of L_{night} in the range 45–65 dBA) and the Disability Weight (DW) of 0.089.

This calculation suggests that there are 24 669 DALYs lost in the Netherlands due to road traffic noise-induced sleep disturbance. Taking 0.04 and 0.10 as the extremes of the range for the weights, the credible range for the DALYs is from 14096 to 35242. This is a very conservative estimate, derived only for the exposure–response and exposure data for road traffic noise and not including the impacts of aircraft and railway noise. However, although the impact at a given exposure level is expected to be higher for aircraft noise (but slightly lower for railway noise), far fewer people are exposed to aircraft (and railway) noise than to road traffic noise.

Conservative estimates applied to the calculation using exposure data from noise maps give a total of 900 000 DALYs lost from noise-induced sleep disturbance for the EU population living in towns of > 50 000 inhabitants.

Outcome based assessment: Uses survey data from the population to assess the relative contribution of various sources of environmental noise to overall self-reported sleep disturbance. This is measured on a scale of 1-10. The three highest points are considered to represent HSD. This approach allows individual sources to be counted more directly.

6.5 CE Delft Report

6.5.1 HACAN Clearskies commissioned CE Delft, an environment and consultancy agency based in the Netherlands to produce a report (published in January 2011) investigating the costs and benefits to the UK of a ban on night flights before 0600. The study used social cost benefit analysis to explore three possible outcomes of a ban:

- All flights and connections are rescheduled to daytime operations
- All flights are scheduled to daytime operations but connections are lost, leading to a decrease in the number of transfer passengers
- All flights currently arriving or departing during the night are cancelled

6.5.2 Social cost benefit analysis identified the direct, indirect and external effects of a night flight ban in monetary terms so that the net costs or benefits can be calculated. In this report the cost/benefits related to welfare effects. The methodology (to be explained in detail in the accompanying worked example report) utilises the correlation between 8 hour Lnight noise exposure and the percentage Highly Sleep Disturbed (HSD) proposed by Miedema (2007). This self-reported sleep disturbance relationship was been assessed for aircraft, road traffic and railway noise by conducting a comprehensive analysis of the pooled original data from 24 studies containing 22771 cases for whom the night-time noise exposure and self-reported noise-induced sleep disturbance, are known.

6.5.3 The polynomial approximation for the percentage highly sleep disturbed (%HSD) is:

$$\mathrm{HSD}(\%) = 18.147 - 0.956 \times L_{night} + 0.01482 \times L_{night}{}^{2}$$

6.5.4 Miedema explains that the above relationships can be applied in the range 40 ≤ L_{night} ≤ 70 dB(A). The relationships are based on data in the L_{night} range 45-65 dB(A) and are expected to give approximations also for lower exposures (40-45 dB(A)) and higher exposures (65-70 dB(A)). It should be noted that the author suggest that there is a need for improving the estimates of the functions that specify the self-reported sleep disturbance in relation to the night-time noise exposure for aircraft noise because the estimated individual variance was very high and the estimated study variance was not fully stable. The cause of this large individual variance is not understood.

6.5.5 The CE Delft report concluded that the impacts ranged from an increase of £860 million to a decrease of £35 million over a period of ten years (2013-2023). The loss would be as a result of all current night time passengers stopped travelling to Heathrow once a night flight ban was introduced. The benefit is explained in terms of the lack of noise-induced sleep disturbance that impacts welfare in the UK.

6.5.6 The analysis used the relationship between L_{night} contours and the odds ratio for hypertension, and relates this to DALYs to obtain a monetary value estimate of the health impact. This is an interesting approach to use, however it should be noted that the authors have compared the benefits of the night flights in the night quota period (2330 – 0600), which equates to 16 flights, with the disbenefits of the whole night period (2300 – 0700). In summer 2009, the average shoulder hour flights per night were 17 (2300-2300) and 52 (0600-0700), so there is a discrepancy of 69 flights per night by only considering the benefit of the flights in the quota period night. The summer 2009 average L_{night} traffic was 82 flights per 2300-0700 night. This considerable difference is an important detail and may invalidate some of the findings in the report.

6.5.7 Further examination of the methodology is required, with the possibility of replicating the analysis to obtain revised figures with respect to equal time period comparisons. It is considered that the social cost benefit approach may be useful for further studies of this nature.

6.6 Interdepartmental Group on Cost and Benefits of Noise (IGCB(N))

6.6.1 The Interdepartmental Group on Cost Benefits of Noise (IGCB (N)) have produced two reports on the valuation of noise impacts. The first, in 2008 examined the impact pathway as a central methodology for assessing noise, linking between the identification of the noise source, modelling and dispersion of noise and then the quantification and monetisation of the impacts. This report identified four groups of noise impacts, namely, health, amenity (annoyance), productivity and ecosystems. Health effects were deemed to be the most urgent are for further research, with the growth in the literature concerning noise and health effects contributing largely to this decision, along with the estimated costs of noise-induced health effects to be in the region of 2-3 billion pounds per year. It was shortly after this report that the IGCB(N) commissioned Bernard Berry and Ian Flindell to conduct an investigation into the links between noise and health. This report (Berry and Flindel, 2009) referred to in section 4 and 6 of this report, was then used by the IGCB(N) to investigate how the findings could be used for cost benefit appraisal methods.

6.6.2 ICGB(N) produced a second report in 2011, which attempted to value the human health impacts of environmental noise exposure. The main findings and recommendations included:

- Acute myocardial infarction (AMI) can be applied into monetary valuation of noise using the 2006 Babisch dose-response function. The IGCB(N) is recommending the use of the Babisch curve to assess the additional risk of AMI with rising noise levels and has generated a methodology which monetises this risk.
- The use of the IGCB(N)'s indicative quantification of hypertension and sleep disturbance impacts to reflect the associated risks in these areas. Dose-response functions identified can be used for sensitivity analysis in policy appraisal, but evidence is not sufficiently developed to monetise these quantified effects. These impacts will instead be presented as the additional risk of incidences given marginal rises in environmental noise levels.

- Continued use of the Department for Transport's WebTAG monetary values for the amenity impacts of noise.
- Prioritising and monitoring policy-oriented research in areas where impacts are believed to be significant, but quantification not sufficiently developed to enable inclusion in the IGCB(N) methodology. Specifically, the IGCB(N) will monitor developments in monetising hypertension and sleep disturbance impacts, and reconciling confounding factors in dose-response functions such as air quality impacts and self-selections bias.

6.7 Health and Safety Laboratory Report

6.7.1 In 2011 Harding et al from the Health and Safety Laboratory published a report on quantifying the links between environmental related noise hypertension and health effects (referred to in Section 4.3 of this report). The aims were to identify the related health outcomes that follow on from hypertension, and to propose a methodology for valuing the links between environmental related hypertension and such health effects. The report focuses on three health outcomes resulting from hypertension; acute myocardial infarction (AMI), stroke and dementia. Calculation of risk was conducted by combining the risk of hypertension associated with environmental noise and the risk of each outcome associated with hypertension. The study investigated 23 urban agglomerations in England and a number of urban and non-urban agglomerations in Wales, representing 43% of the UK population.

6.7.2 The additional cases of AMI, stroke and dementia associated with environmental noise related hypertension in one year from road and railway noise levels Lden ≥ 55 dB(A) were estimated, and the Quality Adjusted Life Years (QALYs) were calculated accordingly (the value of one QALY being taken as £60,000). The QALYs lost to AMI, stroke and dementia due to road noise in the selected study areas were valued at £1,056 million (£286m for AMI, £310m for stroke and £460m for dementia) and for railway noise £43 million (£12m for AMI, £13m for stroke and £18m for dementia). This method, and the recommendations given by IGCB(N) can be used for calculating the associated hypertension and health effects from aircraft noise, which is explained in further detail in the report "Proposed methodology for Estimating the cost of sleep disturbance from aircraft noise".

6.7.3 Harding et al stress that the methodology is dependent on accurate values for the initial risk of hypertension due to environmental noise, and uncertainties in the literature and risk estimates may therefore affect the monetary valuation outcomes.

6.8 A US Perspective

6.8.1 Finegold (2010) highlights that in contrast to the WHO Night Noise Guidelines for Europe, there is no internationally agreed noise metric for estimating sleep disturbance. He notes that past research has highlighted that SEL is a better predictor than L_{Amax} for the number of awakenings, and was the approach taken by DfT (1998) to quantify the impact of night noise.

6.8.2 In order to monetise the loss of amenity resulting from aircraft noise-induced awakenings, a disability weighting is required. To date WHO has only recommended a disability weighting based on the %HSD derived from noise exposure calculated using L_{night}. Thus, whilst SEL is a much better predictor of sleep disturbance than L_{night} it is not possible monetise the loss of amenity associated with noise induced awakenings.

6.9 Acute health effects

6.9.1 As noted in section 4, the WHO NNG (2009) considers that exposure above 55 dB L_{night} brings increased risk of myocardial infarctions:

- 55-60 dB L_{night} odds ratio: 1.1
- 60-65 dB L_{night} odds ratio: 1.2

6.9.2 Whilst there is still much debate, some, including the IGCB(N) consider this outcome should be monetised and added to that estimated from sleep disturbance, the rationale being that for moderate exposure levels sleep disturbance results in only temporary or short term effects, but at higher exposure levels the risk of acute health effects such as myocardial infarction exist.

6.9.3 Because myocardial infarctions are a well-established condition, baseline risk data is available. Secondly, there is an established disability weighting value for myocardial infarctions. Taken together, it is therefore possible to monetise the impact of additional myocardial infarctions due to noise exposure.

6.9.4 Whilst the second report of the IGCB(N) agreed that noise exposure increased the risk of hypertension, it concluded that, because of the number of health outcomes that can arise from hypertension, it was not possible monetise the effects of hypertension. However, a report by Harding et al (2011) prepared for the IGCB(N) concludes that exposure above 45 dB L_{night} brings increased risk of hypertension, and this leads to increased risk of hypertensive stroke and dementia that can be quantified and monetised. Whilst the IGCB(N) has not formally approved the findings it is likely to do so.

6.10 Conclusion

6.10.1 When trying to evaluate the potential cost benefit of aircraft night-time noise in terms of sleep and health effects, it is not possible to use the standard dose-response relationship methodology for all elements due to a lack of evidence of night time specific functions. There is, however, consensus that the percentage highly sleep disturbed dose-response function as proposed by Miedema (2007) and recommended by WHO may be used to monetise the effects of night-time sleep disturbance. It should, however, not be forgotten that this dose-response function is based on self-reported data which possesses a high degree of unexplained variance.

6.10.2 In terms of acute health effects, there is a lack of night-time specific dose-response functions, however, in some instances the WHO considers that the night-time specific risk is as great as the daytime or 24hr risk. What is clear is that is important that equivalent time periods are compared.

6.10.3 The Intergovernmental Group on Costs and Benefits of environmental noise, IGCB(N), has endorsed the WHO recommendations on monetising health impacts due to environmental noise and conducted their own peer review of the research using UK experts.

6.10.4 This review, like that of Berry and Flindell for Defra (2009) considers the work to have a sound methodological basis, and is conducted by credible researchers with strong track records in their fields. The IGCB(N) even comments on UK versus European research:

> "It was felt that national policy appraisal development places unduly high weighting on domestic evidence at the expense of considering valuable external studies in formulating evaluation methodologies. The IGCB(N) does not exclude evidence from other geographic areas; however, it is true that additional weight may be given to national studies. The key reason for this is that as noise is subjective, national studies are seen to better reflect uniquely national characteristics of the domestic population's sensitivities and susceptibilities to noise. However, the IGCB(N) continues to monitor international evidence, and welcomes the formation of the European Network on Noise and Health (ENNAH), which will facilitate this work. At the present time, the IGCB(N) is considering how best it could contribute to this group."

6.10.5 Due to the nature of the methodologies involved in researching the impacts of environmental noise on health it is very difficult to eliminate confounding variables. For example when cross-sectional field studies are used to compare health effects in resident populations in different areas, there are inevitably other variables which could contribute to the observed effects. Similarly, although longitudinal studies that examine the existence of health effects in different population over time are statistically more powerful, the issue of confounding variables still remains. It is also difficult to provide theoretical hypotheses that are capable of explaining the biological pathways by which noise might contribute to adverse health effects and which would be capable of being tested in the field. An obvious example of a confounding variable is the presence of air pollution in conjunction with environmental noise. In terms of participants, the issue of self-selection bias would be considered a confounding variable, along with socio-economic status and lifestyle factors.

6.10.6 Confounding variables such as diet, lifestyle and genetic factors, mean that it is necessary to have large sample sizes in order to achieve the required statistical power. In some cases, existing noise exposed populations will not be large enough in total to provide sufficient statistical power for reliable detection of some of the weaker proposed relationships.

6.10.7 The causal pathways between noise and health outcomes are not yet fully understood and it can be difficult to establish definitive cause and effect. This can result in health outcomes being correlated with available noise indicators, e.g. L_{day}, L_{night} and L_{den}, even though they may adequately represent the noise dose received.

6.10.8 Often, the relationships observed between the input and output variables can be statistically quite weak, even if significant relationships have been found. It is widely agreed within the research community that further work into noise and health is required, particularly in understanding the mechanisms by which long-term exposure to noise may influence health outcomes.

6.10.9 The IGCB(N) report and methodology has been a valuable development for the monetisation of health risks due to environmental noise. This coupled with the Health and Safety Laboratory report (Harding, 2011) allows for progress to be made in assessing the relative risks of primary and secondary health outcomes due to environmental noise. It is a combination of the above methodologies that enables the cost-benefit analysis of night flights to be evaluated. A full breakdown of this methodology can be found in the accompanying technical report “Proposed methodology for estimating the cost of sleep disturbance from aircraft noise”.

7 Summary

7.1 This review has summarised the main findings from research into aircraft noise-induced sleep disturbance and health effects. The findings are not conclusive and are often contradictory, highlighting the practical difficulties in designing studies of this nature. It is often difficult to control for confounding variables such as individual sensitivity to noise, attitudes to aircraft noise, fear, habituation effects, age and gender. In order to obtain the sample sizes required, it is useful to use actigraphy as a means of measurement of sleep, combined with polysomnography where possible and cost allows. Laboratory studies into aircraft noise exposure provide a valuable contribution to the area, as they enable the real-time effects on sleep architecture to be measured, which are often not noticed by the sleeper, yet have follow-on implications for fatigue, daytime sleepiness, performance and mood.

7.2 Laboratory studies, however, often suffer from markedly increased effects, often attributed to a lack of habituation in unfamiliar surroundings. Field studies avoid this, but introduce other difficulties, such as noise intrusion from other sources.

7.3 Notwithstanding these issues, WHO considers that the onset of the effects of noise on sleep occurs at an aircraft noise event level of 32 dB $L_{Amax,indoors}$.

7.4 The work on cardiovascular and hormonal changes that occur during sleep as a result of noise highlight the importance for further work into the area, due to the potential for long-term health effects.

7.5 It would be useful to investigate these effects in larger sample sizes, perhaps alongside other health measures. A long-term study of sleep disturbance in a large sample of subjects, in various sites exposed to aircraft noise would be valuable so the effects over time could be compared within groups. Ideally, it would include subjective data, polysomnography in a selection of subjects at regular intervals, actigraphy, and a regular measurement of stress hormones, although it is appreciated that this is likely to be expensive and would require considerable planning in order to achieve meaningful results.

7.6 Analysis of the economic cost-benefits of night flights is limited to self-reported sleep disturbance and the increased risk of myocardial infarctions. WHO recommends that the percentage highly sleep disturbed is used, along with the disability weighting recommended by WHO in order to monetise the effects of sleep disturbance. The WHO proposes odds ratios for noise-induced myocardial infarctions can be used to estimate the number of additional myocardial infarctions and these can be monetised using established disability weightings from the health sector.

Key findings

7.7 In conclusion, the following key findings must be considered when taking into account cost-benefit analysis of night flights.

- The WHO recommends an interim limit of 55dB L_{night} for the protection of residents against significant noise-induced adverse health effects.
- Percentage highly sleep disturbed (%HSD) can be used to monetise sleep disturbance based on night-time exposure, L_{night}. This measure is taken from self-reported estimates of sleep disturbance.
- Levels above 55 dB L_{night} result in increased risk of myocardial infarctions and these can be monetised using established methods.
- Levels above 45 dB L_{night} result in increased risk of hypertension, and this can lead to hypertensive strokes and dementia, which can be monetised using established methods.

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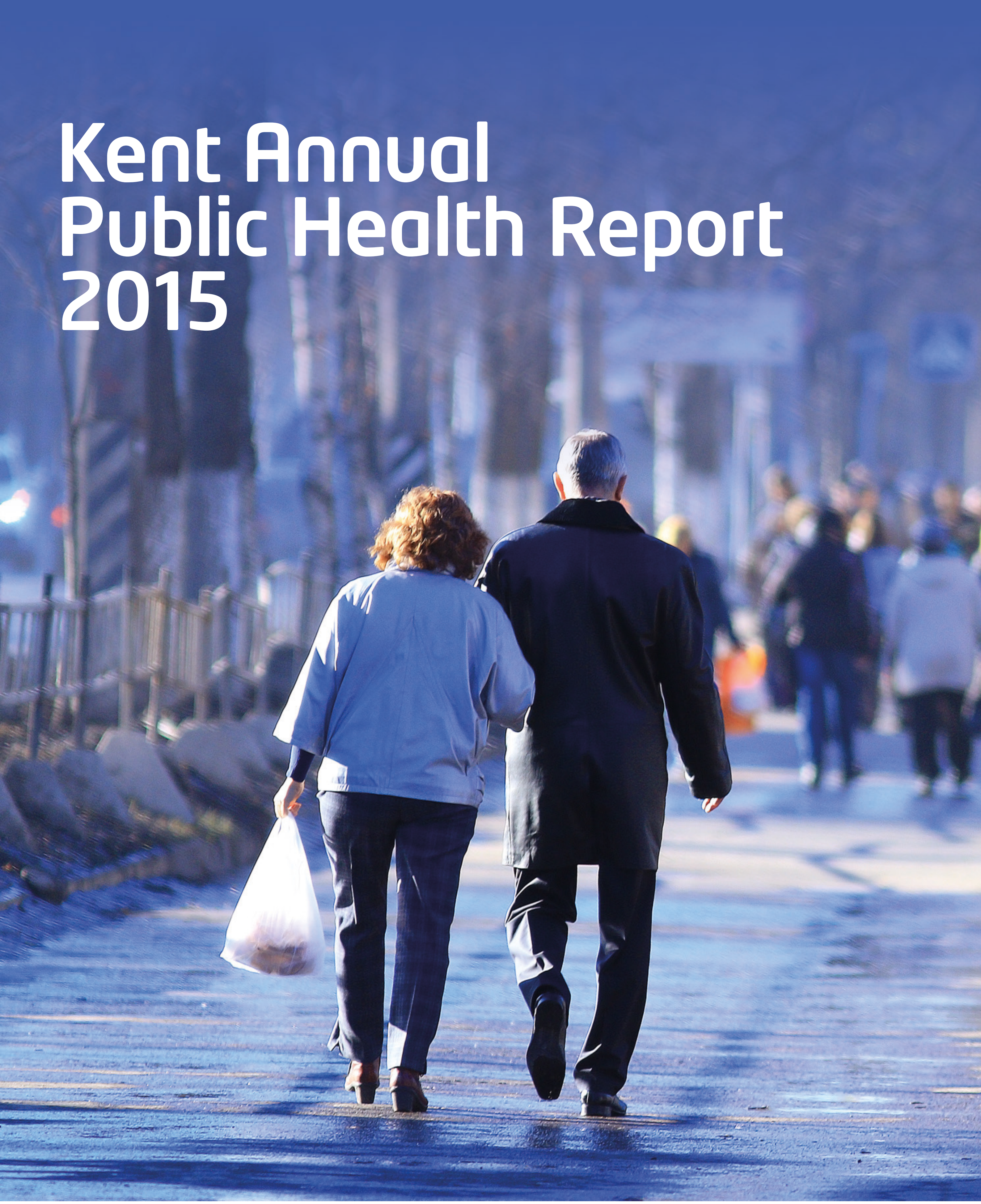

Kent Annual Public Health Report 2015

Health Inequalities

Kent County Council
kent.gov.uk

Foreword

Health Inequalities are the differences in health outcomes within and between communities. We measure health inequalities overall through health statistics such as life expectancy or all-age, all-cause mortality rates or more specifically for specific disease mortality rates such as cancers, cardiovascular or respiratory disease rates. We will also segment populations based on social, environment and health characteristics, for example deprivation, to provide greater understanding of the true nature of health inequalities we see in Kent.

In 2012 Kent County Council agreed to the 'Mind The Gap' action plan which signalled a Kent wide approach to reduce the 'gap' in health outcomes across the county. The action plan followed the key objectives set out in Sir Michael Marmot's 'Fair Society, Healthy Lives' report published in 2010 which set out to propose the most effective evidence-based strategies for reducing health inequalities in England. Those objectives include:

- Give every child the best start in life
- Enable all children, young people and adults to maximise their capabilities and have control over their lives
- Create fair employment and good work for all
- Ensure a healthy standard of living for all
- Create and develop healthy and sustainable places and communities
- Strengthen the role and impact of ill-health prevention

Whilst these objectives remain absolutely important, I'm also aware that the health inequality gap has not closed. I have no doubt that action has and is being taken, however that action is not consistent across the Kent population, the risk being that local work serves to increase health inequalities between communities rather than to reduce them. My annual report of 2015 reflects on where we have got to in Kent, and points to what we need to do in the future if we are going to have any success in narrowing the gap.

[redacted]

Andrew Scott-Clark
Director of Public Health, Kent County Council

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Contents

1 Executive Summary

- **Health inequalities refer to the avoidable differences in health status between individuals depending on their life circumstances. Our health is shaped by the conditions in which we are born, grow, live, work and age.**

- **Reducing health inequalities is a major policy objective both nationally and locally. It is now a statutory responsibility of Local Authorities and the NHS to take action to reduce health inequalities.**

- **Kent's 'Mind The Gap' health inequalities strategy for 2012-15 was successful in raising awareness about the wider determinants of health, and the role of actors both within and external to the health sector in reducing the impact of health inequalities.**

- **This annual report sets out the progress around key indicators of health inequalities and features examples of the initiatives that are having an impact.**

- **Our analysis demonstrates that the most deprived decile populations have disproportionately worse health outcomes, and we can map the geographical locations of these populations in Kent**

- **Moving forward, our health inequalities action plan will be to better work with partners across local government, the health and social care sector, and local communities, to improve health and wellbeing in deprived areas.**

2 Introduction

2.1 What are Health Inequalities?

Health inequalities refer to the avoidable differences in health status between individuals depending on their life circumstances. It is now widely recognised that our health is shaped by the conditions in which we are born, grow, live, work and age [Figure 1]. Whilst Kent scores above the England average on a range of health indicators, this hides significant disparities in health outcomes which exist within and between Kent's communities. Depending on where you are born in Kent, you could statistically be expected to live to the age of 73 years (Margate Central in Thanet) or 90 years (Kingsgate, also in Thanet).

Across England, premature deaths cumulatively represent up to 2.5 million potential years of life lost each year. There are also strong economic arguments for addressing these inequalities. Given the UK's aging population, rising pension age, and cost pressures on the health and social care system, it is vital to ensure that health gradients are reduced and people enjoy more years of life free of disease and disability, ensuring greater economic productivity, self-sufficiency and independence into old age.

Tackling inequalities is a challenge, but there are reasons to be optimistic: informatics and data linkage can provide deep insights into populations like never before; innovative new models of integrated care; smarter commissioning and passionate clinical leaders; exciting and inspiring community-led initiatives. There is now wide recognition right across local government, the NHS, and communities, of the need to address health inequalities in Kent.

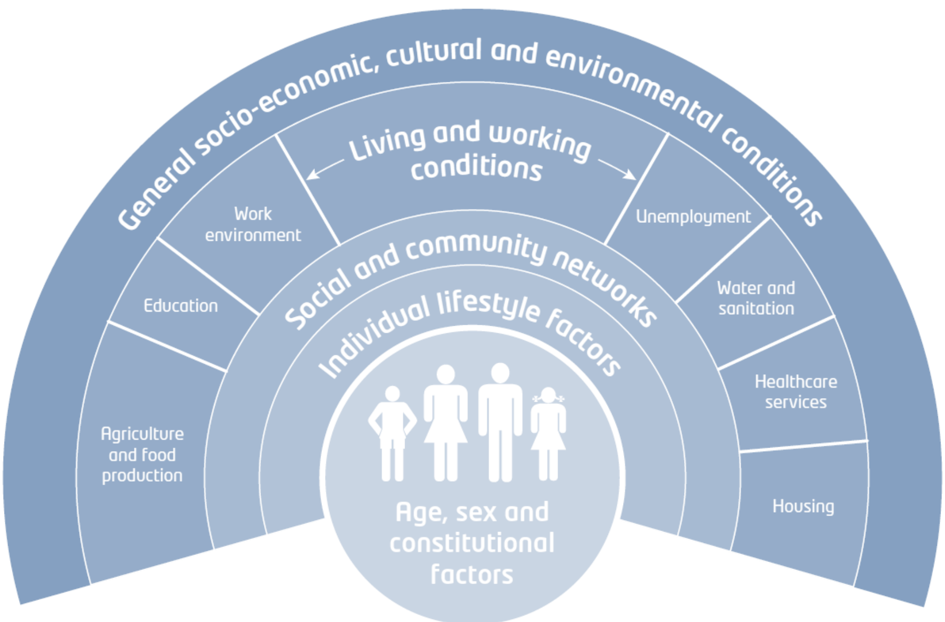


Figure 1 Dahlgren and Whitehead's Social Model of Health (1991)

2.2 The Marmot Review

The latest national strategy to tackling health inequalities, "Fair Society, Healthy Lives", was released in 2010 and is also known as the Marmot Review. Summarising the wealth of new research into health inequalities that had occurred since the previous national strategies into health inequalities; the Acheson Report (1998) and the Black Report (1980), the Marmot Review particularly stressed the action that would be required on the social determinants of health, such as education and employment. It also recognised that inequalities accumulates as we age, beginning even before birth. The six main policy objectives (below) take a 'life course approach' [Figure 2], from the early years through to aging. Kent's performance compared to England is summarised in the table in Appendix 1, showing that Kent is doing better than England on most indicators. Despite this, we know that inequalities continue to exist within and between Kent's communities.

A) Give every child the best start in life

B) Enable all children, young people and adults to maximise their capabilities and have control over their lives

C) Create fair employment and good work for all

D) Ensure a healthy standard of living for all

E) Create and develop healthy and sustainable places and communities

F) Strengthen the role and impact of ill-health prevention

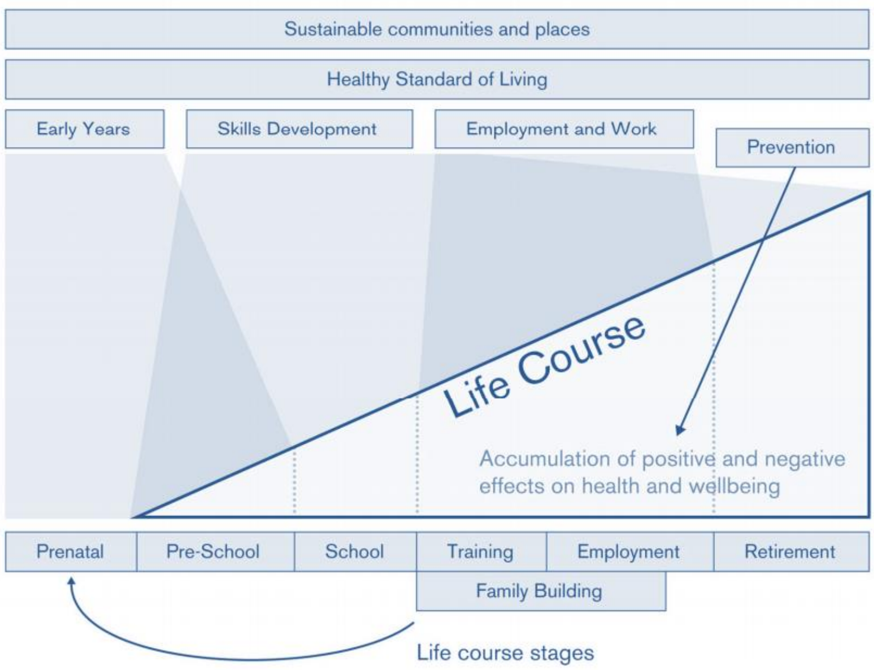


Figure 2 'Life Course' approach from The Marmot Review

2.3 Mind The Gap

In 2012 the 'Mind The Gap' action plan was formulated by Kent County Council to reduce the gap in health outcomes between the least deprived and most deprived communities in Kent. The strategy was an opportunity to produce a unified plan to guide the actions of Kent County Council, district councils, and community partners, in efforts to address the underlying determinants of health. The objectives and priorities for 'Mind The Gap' followed those set out by the Marmot Review.

Since the publication of 'Mind The Gap' responsibility for Public Health in England has shifted from the NHS to local authorities, where the levers exist and partnerships can be made to better influence the wider determinants of health. 'Mind The Gap' succeeded in raising awareness about the impacts other sectors can have on health in the county. Following on from the action plan, a number of Kent's district councils produced their own health inequalities strategies, based on its recommendations. However, systematic action has been variable, limiting the overall impact to reduce inequality.

Now, three years later, we are able to reassess the latest data and renew our efforts to tackling health inequalities. Whilst Kent performs better than the England average on a number of indicators [Appendix 1] there remains significant disparity between the health outcomes of richest and the poorest. A better measure of progress is to see if our efforts are reducing health inequalities across the county.

3 Health Inequalities in Kent Today

The level of deprivation for a particular geographic area can be measured by the 'Indices of Multiple Deprivation', a national scoring methodology which includes multiple factors: income, employment, education, skills, health, crime, housing and the environment.

The map below shows how deprivation varies across Kent, with darker areas being wards with higher levels of deprivation [Figure 3]. This shows that deprivation in Kent tends to be higher in the eastern parts of the county than the western parts. Deprivation also tends to be higher in coastal towns and urban centres. There is also rural deprivation in some areas, related to less access to services.

For most health issues analysed (e.g. smoking prevalence, obesity rates, mortality rates and life expectancy), what we find is that the areas of higher deprivation have worse health outcomes. This is not a surprising finding and nor is it unique to Kent. It has long been known in the field of public health that poorer populations tend to suffer from poorer health.

Are health inequalities reducing in Kent? One way of assessing this is looking at how mortality rates have changed over time for the most affluent and most deprived populations.

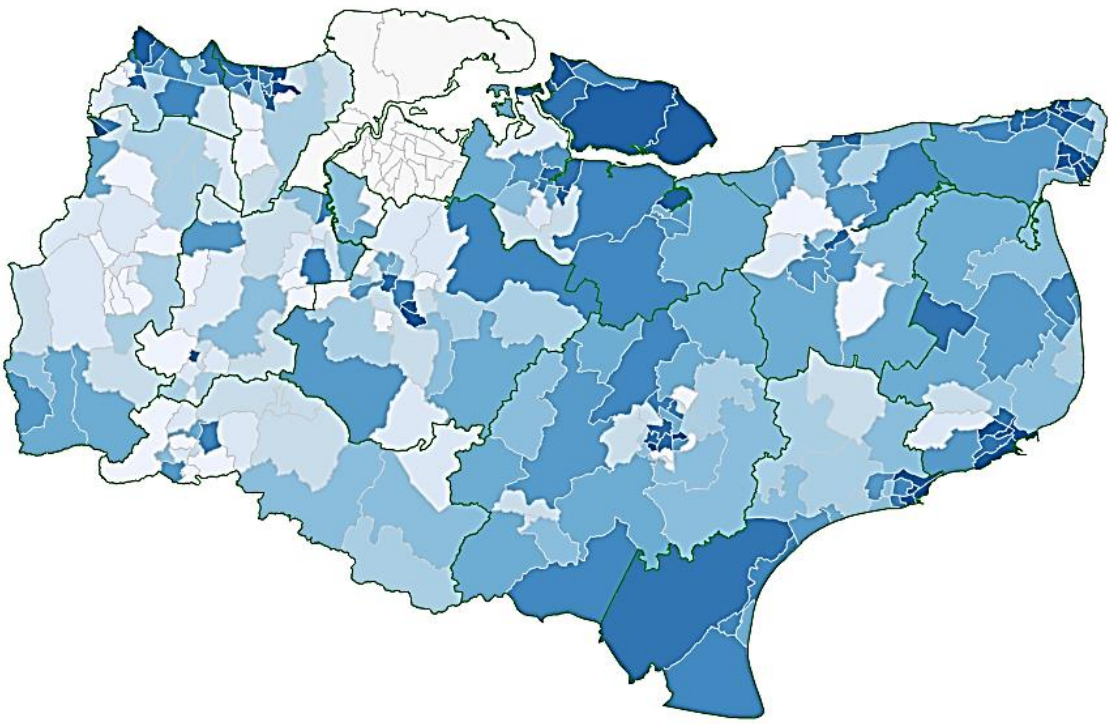


Figure 3 Indices of Multiple Deprivation (IMD) 2015, ward map of Kent

Figure 4 shows the change in mortality rates in Kent over the last decade, with the top line showing the most deprived population and the bottom line showing the least deprived population. Mortality rates are decreasing across all groups (all the lines are decreasing). This is a significant success for our population; we are all living longer in Kent, across all groups in society.

But *the gap* between the top line and bottom line remains unchanged. So the difference between the mortality rates of the most and least deprived is not changing. In order to close 'the gap', we need to speed up the rate of reduction in mortality rates in the most deprived decile.

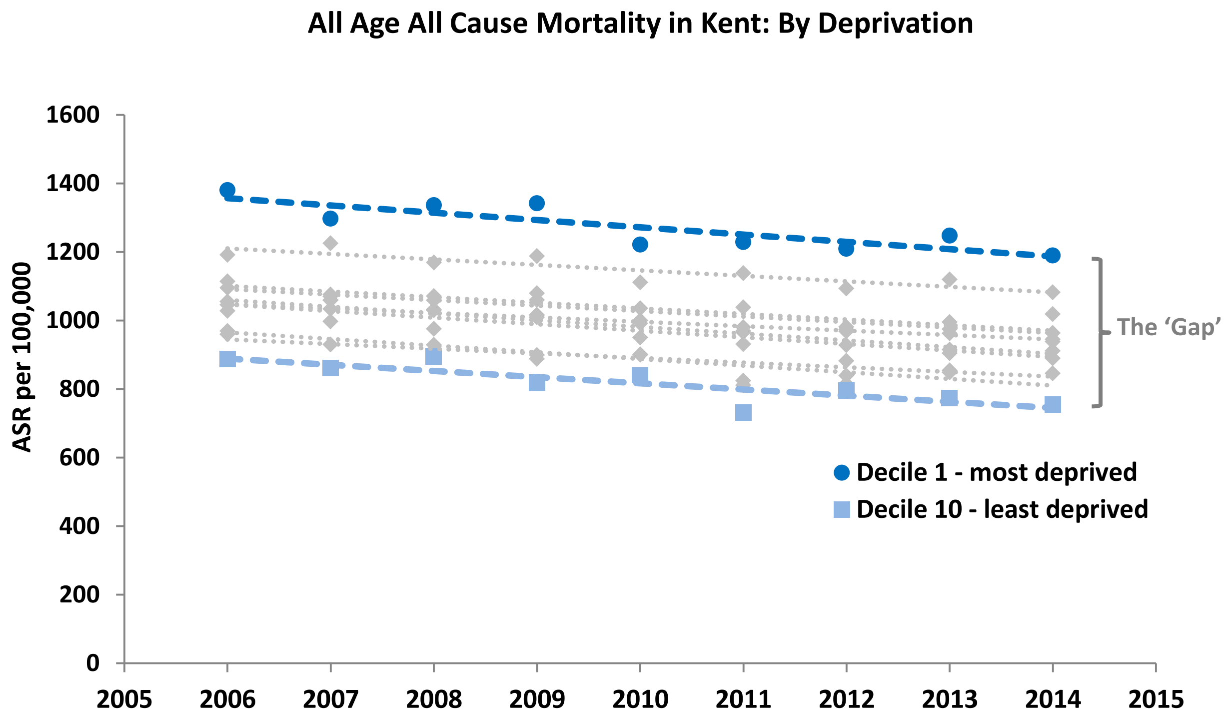


Figure 4 **Changes in Mortality Rates in Kent by deprivation decile (2006-2014)**

Inequality in Mortality Rates

The gap in mortality rates between the most and least deprived remains unchanged in Kent over the last decade

In the following chapters in this report, we will look at each of the six Marmot policy objectives and consider the progress that has been made in Kent, with examples of good practice.

A) Give every child the best start in life

A child's early years lay down the foundation for the rest of their life, and the first three years are the most critical. This is a crucial period of physical, intellectual and emotional development.

Inequalities are introduced before birth, as the health of a child is greatly affected by the health of their mother during pregnancy. Maternal stress, diet, smoking, drug and alcohol use all influence a baby's development in the womb. **Low birth weight** and premature delivery are both associated with social disadvantage and lead to poorer health outcomes.

The percentage of term babies with a low birth weight in Kent has been stable at about 2.3%. The rate of **still births** is about 4.6 per 1000 total births, and the **infant mortality** rates have decreased in recent years to 2.9 deaths per 1000 births live births. One area that has been highlighted in Kent is the number of sudden unexpected deaths in infants that are related to co-sleeping, and a campaign is being formulated to raise awareness.

Smoking in pregnancy is an adverse health behaviour that is known to impact on foetal development in the womb. Smoking status at time of delivery has been reducing in Kent over the last few years, but the county rate of 12.6% is above the national average of 11.4%. The figure varies within Kent; in Swale as many as one in five pregnant women continue to smoke.

Breastfeeding contributes significantly to the long term health of both infants and mothers, and increases maternal bonding. The breastfeeding initiation rate in Kent has decreased over the last few years and is now 71.3%, which is below the national average (74.3%).

Babyclear Programme

Babyclear is an intervention to support pregnant women to stop smoking and have healthier babies. The programme is delivered by midwives, who perform a carbon monoxide test in all pregnant women, and refer those who smoke directly into stop smoking services. The training has received good feedback and is being delivered to all midwives in Kent.

Breastfeeding Group

Swale has a particularly low rate of breastfeeding initiation. The CCG has therefore set up a multi-agency project group over the last 2 years. One example of their work is collaboration with the Best Beginnings charity and their 'From Bump to Breastfeeding' resource. The group is currently developing a formal breastfeeding pathway for Swale.

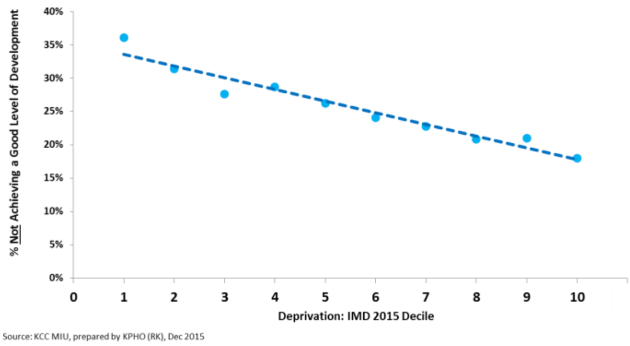


Figure 5 **School readiness by deprivation, Kent 2013**

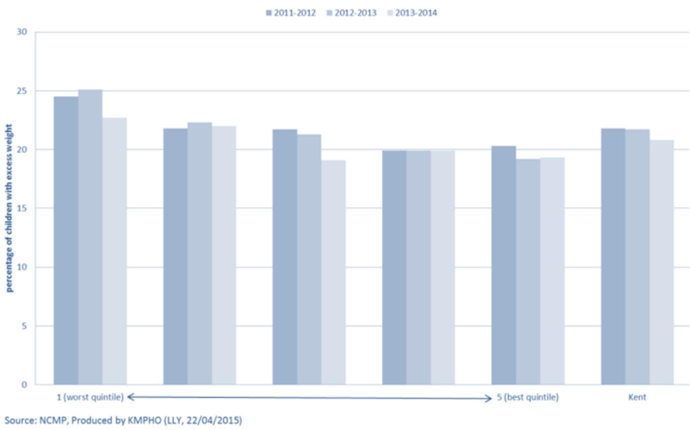


Figure 6 **YR childhood obesity by deprivation 2011-2014**

Teen pregnancy has adverse effects on both mother and child. Babies born to teen mothers are more likely to be born into poverty, do less well at school, and are more likely to become teenage parents themselves. In Kent, the under-18 conception rate has fallen dramatically over the last decade to 22.2 per 1000. However, rates are still higher than this in areas of deprivation.

After birth, the first few years of life are crucial in shaping a person's life chances. The development of early cognitive ability is strongly associated with later educational success, income and better health. Figure 5 shows how **school readiness** (or 'good childhood development') varies by deprivation in Kent, with more deprived deciles having a higher proportion of children who do not achieve a good level of development.

Our experiences in childhood affect behaviours and habits which persist into adulthood. Even at the young age of 5, there is already a social gradient in **childhood obesity** rates in Kent [Figure 6]. There has been a marginal improvement in Reception Year (YR) obesity rates over the last few years. Family Weight Management Programmes, such as 'Go For It' in Maidstone, provide advice and promote behavioural modifications to improve lifestyles.

The Family Nurse Partnership

The Family Nurse Partnership is an intensive, evidence-based preventive home visiting programme to teen mothers in Kent (including their partners) delivered by specially trained nurses from early pregnancy until the child is 2 years old. The aims are to improve maternal health during pregnancy, child health and development, and parents' economic self-sufficiency. Operating in parts of Kent, the service is targeted at districts with the highest teenage pregnancy rates. Family Nurses are highly skilled and successful in engaging young parents, and have a high retention rate. Some of the core elements of the FNP programme are reducing rates of smoking, reducing A&E attendances and hospitalisation, increasing rates of breastfeeding and improving maternal health. The programme also supports young parents in returning to education, training, or employment. Feedback from parents continues to be overwhelmingly positive.

B) Enable all children, young people and adults to maximise their capabilities and have control over their lives

The accumulation of experiences during childhood shapes both the choices they will make as adults as well as their long term health. Schools and families together have important roles in promoting the development of children - physically, socially and emotionally, as well as cognitively. Low educational attainment is closely associated with poorer health outcomes.

Education is impacted not just by schooling, but also by family background, neighbourhoods and peer groups, and is therefore closely associated with deprivation. Figure 7 shows how **GCSE attainment** varies across Kent, with darker areas showing a lower proportion of children achieving 5 GCSEs graded between A* and C. Compared to the Kent average of 58%, only 27% of children receiving free school meals achieve 5 good GCSEs. The **attainment gap** has been recognised as an area for improvement, and is key to reducing inequalities.

It is also important to focus on young adults in the years after compulsory education, which is a key transitional period into adulthood. Young people age 16 to 25 are those most likely to be unemployed or in low-skilled jobs. Kent's *Learning, Employment and Skills Strategy* is showing significant progress, and the number of 16-18 year olds **'Not in Education, Employment or Training'** has continued to fall, to under 5%.

However, childhood development is not just about educational attainment. We should also enable children to develop their personalities, talents, self-esteem and resilience, to allow them to lead flourishing lives. Activities such as sport, music, drama and the arts allow children to develop well-rounded skill sets and such

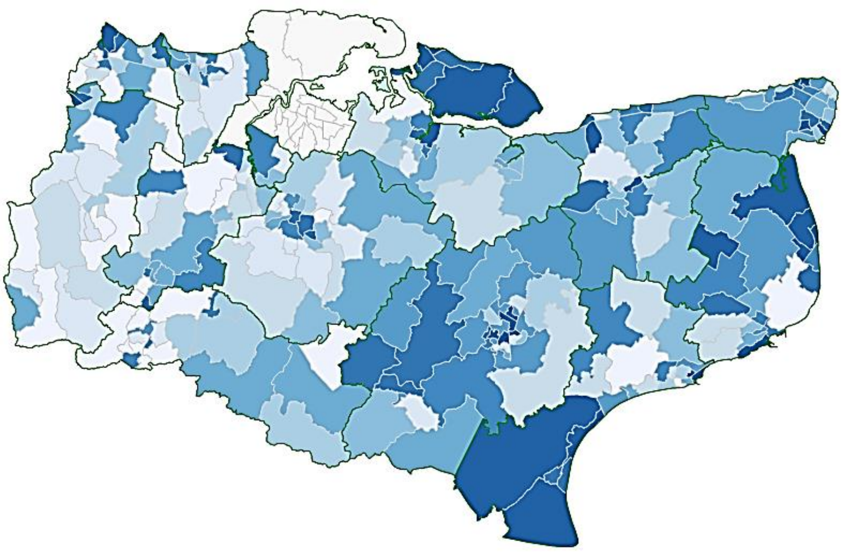


Figure 7 GCSE Attainment, 2013, ward map of Kent

opportunities should be fostered both by schools and local communities. Extra-curricular activities can help to keep children physically active and reduce obesity. **Year 6 obesity** rates, which demonstrate a social gradient, have shown no improvement over the last few years [Figure 8].

Emotional wellbeing and mental health is another important area for children and young adults. Nationally, rates of **mental illness** continue to increase. This is significant as mental wellbeing and resilience underpins other health behaviours and "there is no health without mental health". Rates of mental illness in Kent continue to be strongly associated with areas of deprivation. There are varying levels of need which requires a 'whole system' approach to support children and young people (from early help through to specialist services). An example initiative is the *HeadStart* programme running in Thanet, Canterbury and North West Kent for 10-14 year olds.

A group that have particularly complex and health and social care needs are **asylum seekers and refugees**. Since 2014 there has been a significant increase in the numbers of unaccompanied asylum seeking children (UASC) in Kent, a group with a high prevalence of psychological symptoms.

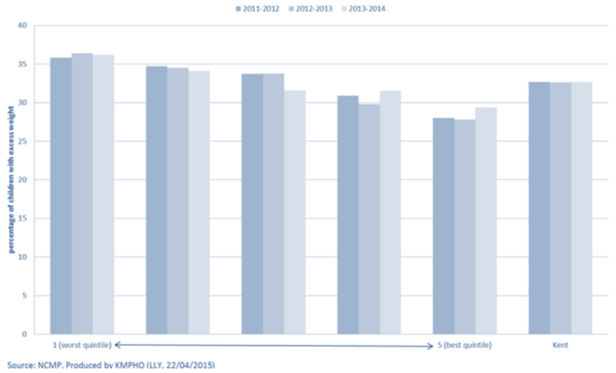


Figure 8 Year 6 obesity rates by deprivation 2011-14

Troubled Families

This programme aims to improve the life chances of Kent's most disadvantaged families. A dedicated worker builds a relationship with the family, assessing needs and coordinating services. The four main aims are to reduce school absence, antisocial behaviour, offending rates and unemployment. Kent achieved its targets for phase 1 of the programme and is expanding to include more families and wider criteria in line with phase 2 of the national programme.

Emotional wellbeing is defined as:

"a positive state of mind and body: feeling safe and able to cope, with a sense of connection with people, communities and the wider environment." **WHO 2004**

C) Create fair employment and good work for all

Patterns of employment both reflect and reinforce the social gradient, and being in good employment is protective of health.

Unemployment leads to financial insecurity, psychosocial stress, anxiety, depression and unhealthy behaviours such as smoking and alcohol consumption. A vicious cycle can be created, as the resulting ill-health and disability can further reduce the likelihood of ever returning to employment.

Rates of **unemployment** are highest among those lacking qualifications, people with disabilities and mental ill health, those with caring responsibilities, lone parents, older workers, and young people. Figure 9 shows the Job Seekers Claimant rate across Kent, which closely correlates with areas of higher deprivation.

In Kent, the unemployment rate has been reducing over the last few years in all districts, as the nation's economic recovery continues [Figure 10]. The unemployment rate overall is 5.0%, less than the England average (6.0%).

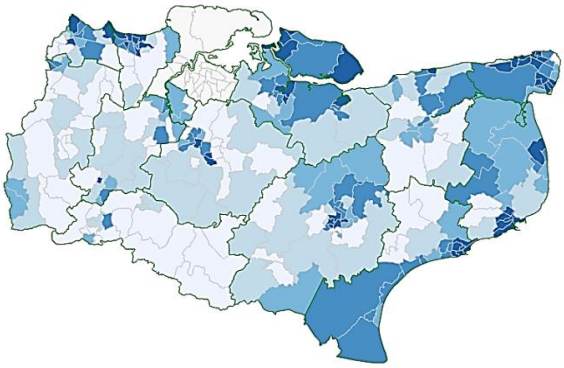
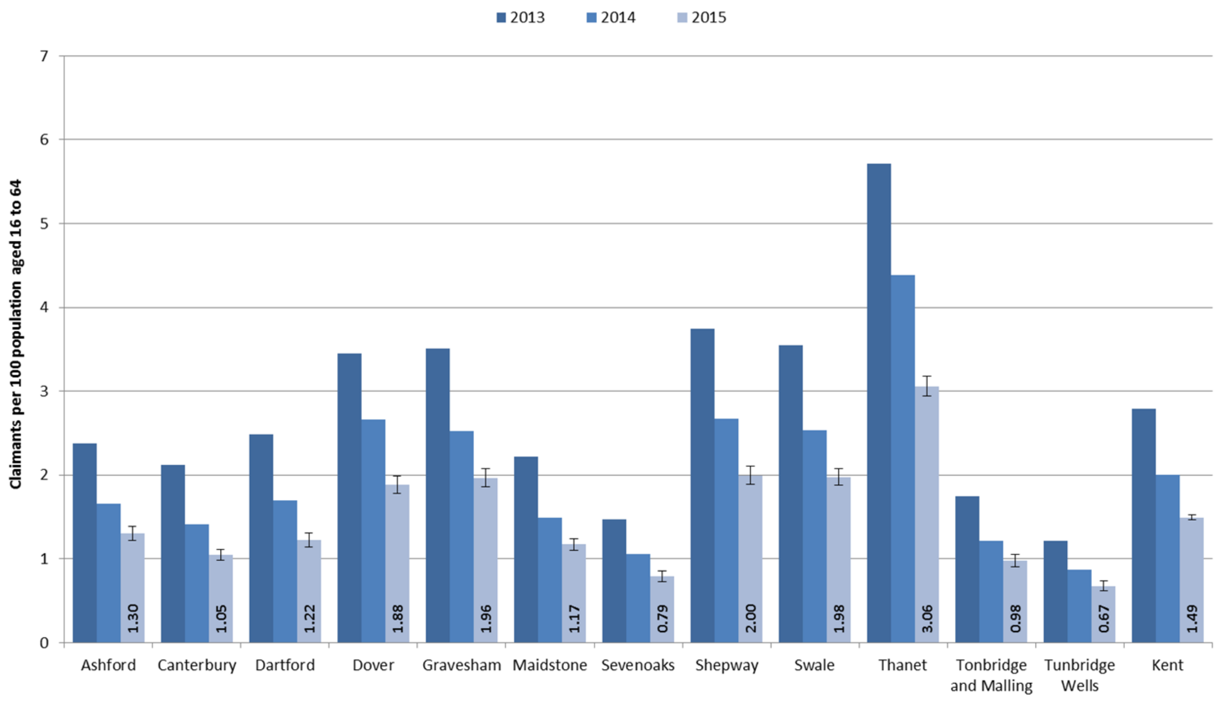


Figure 9   Job seekers claimant rate in Kent, 2015

The **quality of work** is also important. Jobs that are insecure, low-paid and fail to protect employees from stress and physical danger lead to poorer health. Common work-related illnesses include mental health problems and musculoskeletal disorders. The largest industry group in Kent is the professional, scientific and technical industry (17.4%) and the construction industry is the second largest (15.1%). Kent also has a high proportion of small businesses; 76.5% of all Kent's businesses employ 1-4 people.

Businesses and workplaces have a key role to play in supporting good health and reducing health inequalities. Supervisor and peer support, stable rotas, safe conditions, opportunities for training and promotion, and greater autonomy in the workplace are all factors that increase employees' wellbeing. Better **workplace health** can be promoted through healthier food options and opportunities to increase physical activity.



Source: NOMIS, prepared by KPHO (ES), 04/16

Figure 10 **Unemployment rates in Kent by district - 2012, 2013, 2014 (percentage of workforce age 16-64 unemployed)**

Health at Work

The Kent Healthy Business Awards programme provides business engagement across the system to promote health at work, improve access to preventative services and encourage healthy lifestyle choices across the Public Health agenda. The awards are based on the National Workplace Health and Wellbeing Charter, with 9 main themes:

- leadership
- attendance management
- health and safety requirements
- mental health and well being
- smoking and tobacco
- physical activity
- healthy eating
- alcohol and substance use
- environment

Currently, Kent Healthy Business advisors based within district local authority teams are working with approximately 200 businesses of which at least 85 (32,287 employees) have signed their commitment and are working towards the standards. In 2015, eighteen businesses achieved awards. The golden thread running through the standards is leadership, communication and culture, with a commitment to improve staff health and wellbeing.

The Workplace Challenge is a Kent wide campaign by Kent Sport that gives businesses the chance to win points and prizes in friendly competition by allowing employees to log the amount of physical activity they are doing. For more information, visit http://www.workplacechallenge.org.uk/kent/

D) Ensure a healthy standard of living for all

Income is a key determinant of health. Insufficient income is associated with worse outcomes in long term health and life expectancy. The **median income** in Kent has risen steadily since 2002 by 31.5%, though there remain significant differences between the districts [Figure 11]. In the forthcoming years those on low wages in Kent will be affected by welfare reform and national policy changes to taxation, benefits, and the minimum wage. **Financial debt** can have a significant impact on mental wellbeing, stress and anxiety.

Income alone does not give a full picture of living standards. **Housing** is a key aspect of inequalities; indeed, the most visible marker of areas of deprivation and affluence in Kent is the housing found in those areas. Poor quality housing is a risk to health, and rates of over-crowded accommodation and shared dwellings in Kent are strongly associated with levels of deprivation.

Private rental prices have increased [Figure 12] so that a greater proportion of pay is spent on housing. Whilst wages have been increasing recently in Kent, the increase has been below the rise in the cost of housing.

House prices have risen steadily in Kent and the average house price is now around £300,000. This is decreasing the prospects of home ownership for many, and is leading to widening inequalities.

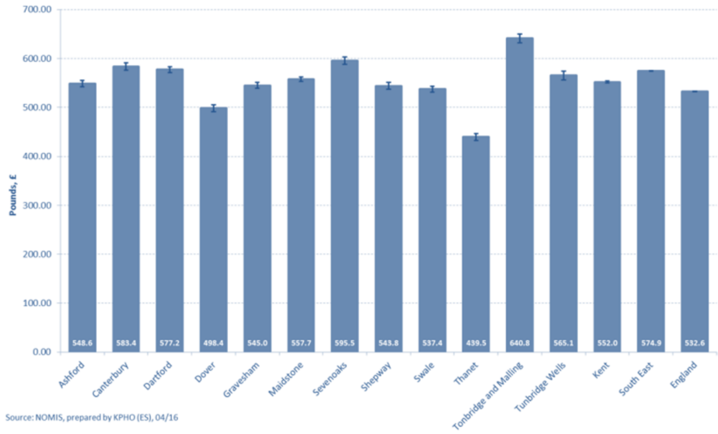


Figure 11 **Gross median weekly wage in Kent 2015 (full-time)**

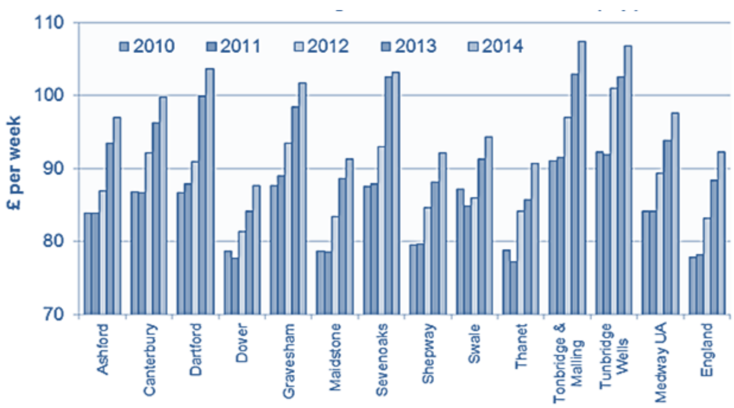


Figure 12 **Private rental price changes in Kent districts 2010-2014**

Fuel poverty affects the ability of individuals to live in warm housing. Cold temperatures affect the immune system, leaving elderly individuals at increased risk of infections, respiratory disease and cardiovascular disease. The fuel poverty rate in Kent was 8.6% in 2013, less than the national rate of 10.4%. The number of **excess winter deaths** in Kent dropped from 925 in 2012/13 to 589 in 2013/14.

Child poverty has reduced by 1% in the last year, but still 16.5% of all children in Kent live in poverty. While below the national average of 18% this nonetheless constitutes over 50,000 children in Kent living in poverty. Over two thirds of the children in Kent living in poverty live with a lone parent.

Certain vulnerable groups in Kent are more susceptible to poorer health. **Rough sleepers**, who lack food, shelter, and warmth, are at risk of a wide range of health problems. The lack of an address makes it difficult for this group to register with a GP and access primary health care services, leading to an overreliance on acute health care services, such as A&E.

Homelessness can also be more hidden in the form of temporary accommodation (sofa surfing, squatting, hostels, B&Bs). This transient living can lead to poor continuity of care and service provision. In Kent, the number of households accepted as homeless and in priority need has been increasing since 2010.

Think Housing First

The impact of housing on the population's health is significant and crucial. Modern legislation continues to address many of the issues brought up in the 1840 select committee report on the health of our towns. However, the challenges faced by some households to secure good quality, safe, accessible, affordable homes has resulted in a necessary range of public and voluntary sector organisations working across the sector through a variety of programmes and interventions, including:

- New affordable housing provision
- Interventions to ensure homes are safe, warm including actions arising from HHSRS (health & housing safety rating system) assessments
- Housing assistance through grants or loans, including Disabled Facilities Grants to make homes accessible for disabled and frail adults and children
- Homelessness prevention for vulnerable households
- Emergency accommodation where homelessness can't be prevented
- Housing related support
- Landlord licensing and accreditation schemes to ensure at least minimum standards are met

Joint Policy and Planning Board, together with Kent Housing Group, has developed a strategy, *Think Housing First*, which recognises the impact of housing on health inequalities. All objectives within the Think Housing First action plan support the six main policy objectives of the Marmot Review. Each of the housing related actions within the plan have been designed in partnership with all of the appropriate organisations, to ensure commitment to improve health outcomes and deliver added value to the above work programs for the benefit of Kent residents.

E) Create and develop healthy and sustainable places and communities

Creating a physical environment in which people can lead healthier lives is crucial to tackling health inequalities. **Green spaces** such as parks, woodland and other open spaces are associated with a number of health outcomes, relating to physical health, mental health and general wellbeing. There are many indirect benefits too, for example, providing space for social activity, sports and recreation, and improving the air quality. [Figure 13] shows how **'Living Environment'** varies across Kent by deprivation, with worse scores in more deprived areas.

The Kent countryside, the 'garden of England' is a great asset for the county, economically, culturally and socially, and green space constitutes 85% of the land area in Kent.

It is important to understand how such assets can be used to promote healthy physical activity. Currently, 28.4% of adults in Kent are **physically inactive**, being active for less than 30 mins per week, when the national recommendation is for 150 minutes per week.

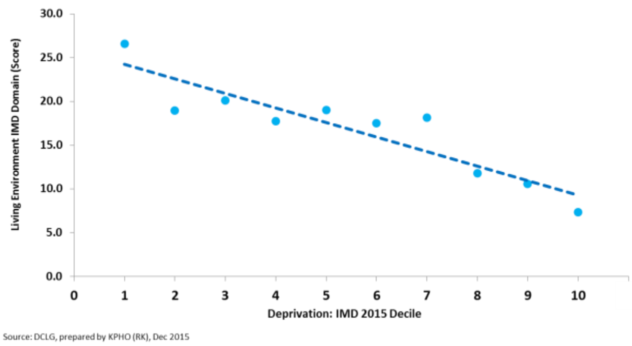


Figure 13 **Living Environment scores by deprivation in Kent, 2011**

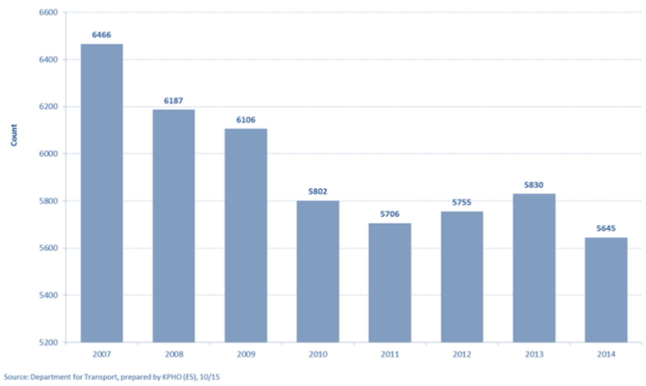


Figure 14 Casualties on Kent roads 2007-2014

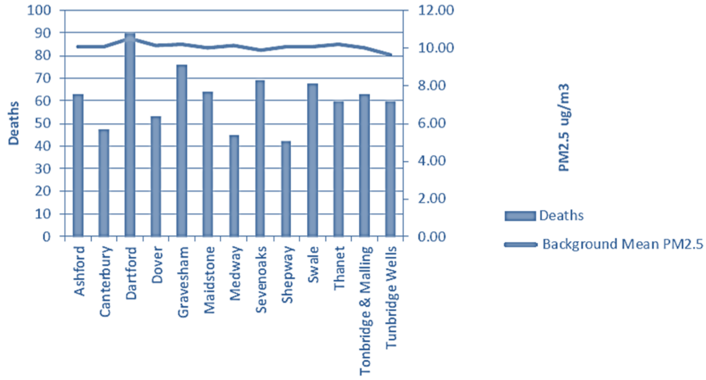


Figure 15 Deaths per 100,000 due to air pollution from fine particulate matter (PM2.5) in Kent, 2011

The impact of **transport** on health is complex and multifactorial – increasing access to work and services, but also contributing to greenhouse gas emissions, physical inactivity and outdoor noise and air pollution. Use of public transport eases traffic congestion, increases physical activity and reduces gas emissions. 71% of Kent residents travel to work by car.

Road traffic injuries are a significant public health concern as a major avoidable cause of death, particularly among children and young people. The number of casualties from road traffic accidents has decreased in Kent in recent years [Figure 14].

Poor air quality is another concern that drives health inequalities and premature mortality from cardio-respiratory diseases. Using background readings of fine particulate matter (PM2.5) in the air, we can estimate the number of related early deaths that occur each year in Kent [Figure 15]. Air pollution tends to be worse close to busy roads, where poorer communities often live.

The Marmot Review proposes that reducing health inequalities and **environmental sustainability** go together. Creating communities with a focus on real wellbeing aligns well with the climate change agenda, by creating the conditions that enable everyone to flourish in a way that is sustainable.

As well as natural assets, Kent has a rich cultural heritage, and Kent is now part of a national pilot programme to facilitate the commissioning of the **arts and culture** for public health. Twelve arts and cultural organisations are now working with existing mental health providers to deliver a range of activities, with further plans to engage eight local reading, singing, writing and dance groups.

Smoke Free Parks

The aim of this pilot project in Ashford and Canterbury is to encourage self-enforced smoke free zones in areas where children play, in order to reduce their exposure to second hand smoke. The signage has been co-designed and created by local people. Details of local stop smoking services are also included in the signs, to signpost individuals who may benefit from these services. The local response has been very positive.

Outdoor Gyms

Gym membership can be prohibitively expensive. Outdoor gyms, common in other countries, can be used as a free resource to encourage physical activity and getting outdoors. Most existing outdoor gyms are in affluent areas in Kent. KCC funded outdoor gyms in Sherwood and Gravesend, together with instructor-led sessions, and have received positive feedback from service users.

Live Well Kent

'Live It Well' is Kent's mental health and wellbeing strategy. This gave priority to promoting wellbeing as a cost effective preventative intervention, and placed particular focus on tackling health inequalities by targeting those groups at risk of poor wellbeing and low resilience. Public Health commissioned a series of targeted projects between 2013 and 2015, using an asset-based approach to improve wellbeing across the county, ranging from Men's Sheds to Creative Arts Projects. Part of the programme was a communications campaign that encouraged people to adopt behaviours that can improve their mental wellbeing. This can be summarised into six simple steps: 'The Six Ways to Wellbeing' (below), which are based on research by the New Economics Foundation. The learning from this programme will feed into a new Community Mental Health and Wellbeing Service called 'Live Well Kent'. The service began in April 2016 and is a free service for anyone over 17 living in Kent. More information can be found at: http://livewellkent.org.uk/

Body: be active
Mind: keep learning
Spirit: give
People: connect
Place: take notice
Planet: care

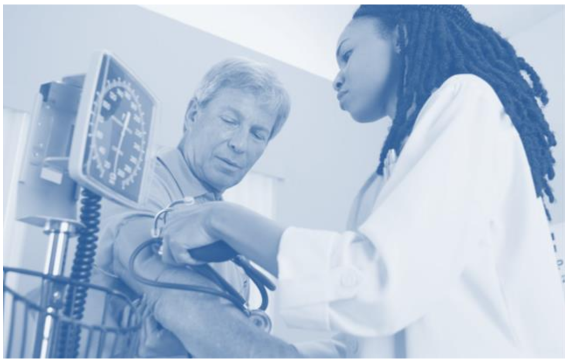
Kent Sheds

Social isolation becomes more common as we age. This Kent-wide initiative provides the opportunities for men to participate in practical group activities such as engineering projects, woodworking or gardening. Here, they can share and learn new skills, and support one another by working together 'shoulder to shoulder', thereby developing friendships. The aim of the programme is to increase population wellbeing, reduce risk of suicide, and aid and improve resilience. There are currently 27 sheds across Kent, and the initiative supports groups and organisations to set up their own 'sheds'. Feedback is very positive, with 91% of participants reporting improved wellbeing. More information can be found at http://www.kentsheds.org.uk/

F) Strengthen the role and impact of ill health prevention

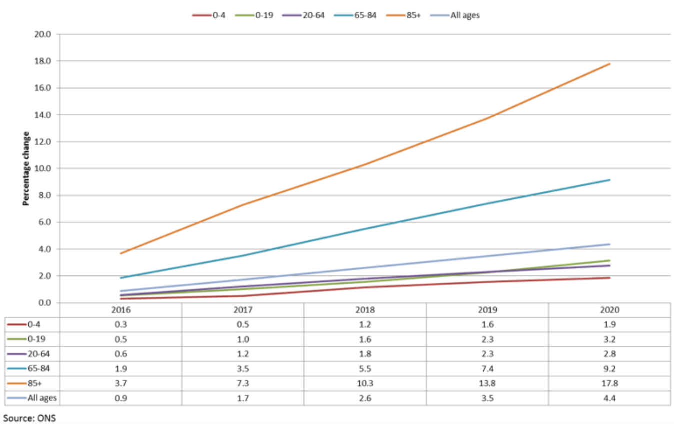
The previous policy objectives of the Marmot review focus on the social determinants of health, the most upstream underlying causes of health inequalities. Yet there are also interventions that can happen more downstream to promote healthy behaviour and ill health prevention, across the NHS, local government and communities. For example, Making Every Contact Count (MECC) is a national programme to ensure all NHS staff are trained to engage in conversations about healthier lifestyles. **Smoking** prevalence in Kent has been decreasing, from 21.7% in 2010 to 19.1% in 2014. Rates of **obesity**, as for smoking, are higher in more deprived areas in Kent. Premature mortality caused by **alcohol** is six times higher in the most deprived areas compared to the most affluent areas.

The **NHS Health Check** programme is a national cardiovascular screening programme for all individuals aged 40-74 who are not already being treated for cardiovascular disease. Since CV disease will affect many people as they age getting this five-yearly check of blood pressure, weight and cholesterol is a way of identifying risks and



getting advice and support to change lifestyles for the better. The proportion of the eligible population receiving a Health Check in Kent is 17.4%, compared to 18.6% nationally. Healthcare advances over the decades mean that we are all living longer; mortality rates have fallen across the board in Kent, and we have an **ageing population** [Figure 17].

However, we are also spending a greater proportion of our lives in ill health, and more deprived populations in Kent face a greater degree of **long term disability** [Figure 16], which reduces the ability to work and enjoy life. Addressing this is one of the great challenges facing not only public health, but also the wider Kent economy; 7.6% of residents claim some form of disability benefit.



	2016	2017	2018	2019	2020
0-4	0.3	0.5	1.2	1.6	1.9
0-19	0.5	1.0	1.6	2.3	3.2
20-64	0.6	1.2	1.8	2.3	2.8
65-84	1.9	3.5	5.5	7.4	9.2
85+	3.7	7.3	10.3	13.8	17.8
All ages	0.9	1.7	2.6	3.5	4.4

Figure 17 **Projected population changes in Kent from 2015 to 2020 by age group**

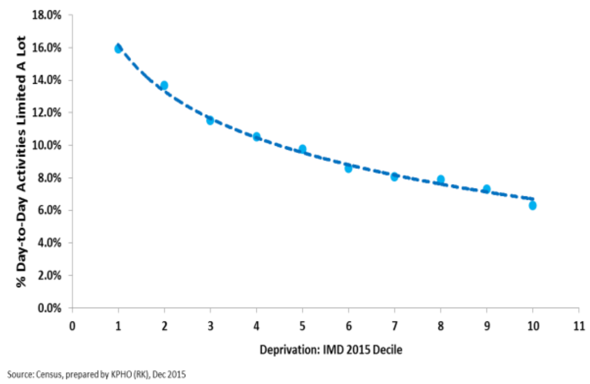


Figure 16 **Long term illness and disability in Kent by deprivation, 2011**

Managing the growing burden of chronic disease will require us all to lead healthier lifestyles, and better self-manage chronic conditions at home and in the community.

However, deprived populations have lower rates of uptake of preventative health services. A key challenge for **primary care** in addressing health inequalities is to reach out to deprived communities to make sure they are registered and aware of the services available. A number of initiatives aim to increase awareness of and engagement with Health Improvement services (below).

End-of-life care is another area which exhibits inequalities in healthcare provision, as deprived populations are less likely to receive specialist palliative care. Surveys indicate that people overwhelming prefer to die in their own homes, yet nearly half of all deaths in Kent still occur in hospital. This figure is decreasing with better end of life care planning. All of us have the right to a good death. This issue has been recognised by Kent CCGs who are taking a whole population approach to improving pathways for the end of life across acute and community care.

Health MOT Roadshow

This is a free mobile health initiative in Maidstone, designed to engage with harder-to-reach individuals and signpost to health services. A branded mobile health unit, with an 'Interactive Health Kiosk' inside, is used by the team in a variety of outreach settings, such as shopping centres, supermarkets, community centres, and places of worship. The Interactive Health Kiosk allows individuals to self-test key indicators such as: weight, body mass index, body fat content, heart rate and blood pressure. Each 'Health MOT' is performed in around five minutes, and can lead to referrals or signposting to services to better manage these risk factors.

Making Every Contact Count

Making Every Contact Count is a national programme to better train and support health professionals to deliver lifestyles advice to promote health. This ranges from brief advice, to more advanced behaviour change techniques and signposting towards support and services. We are now expanding MECC to sectors outside of health, as everyone who comes into contact with members of the public has the opportunity to begin conversations about health. Kent, Surrey and Sussex are currently piloting a MECC e-learning programme and two day training session with Housing providers in Kent, using funding provided by Health Education England.

Healthy Living Pharmacies

The HLP programme aims to support pharmacies to promote healthier lifestyles and behaviour change and through commissioned public health services. To date 111 pharmacies have registered to become HLPs, and 173 Health Champions have been trained in total. Many pharmacies are now undergoing a process of accreditation. With increasing pressure and demand on the health service, pharmacies have a key role to play improving the health and wellbeing and helping to reduce health inequalities in local

4 Life Expectancy and Deprivation

The more affluent you are, the longer you are likely to live, and this phenomenon is as true in Kent as it is across England and around the world. The health inequalities discussed throughout this report accumulate throughout life as we age, resulting in worse health outcomes in the most deprived populations. Figure 18 shows how the most deprived decile populations in Kent have a disproportionately lower life expectancy, considerably worse than even the slope gradient. We can map geographically the locations of these populations that feature in the most deprived decile in Kent [Figure 19].

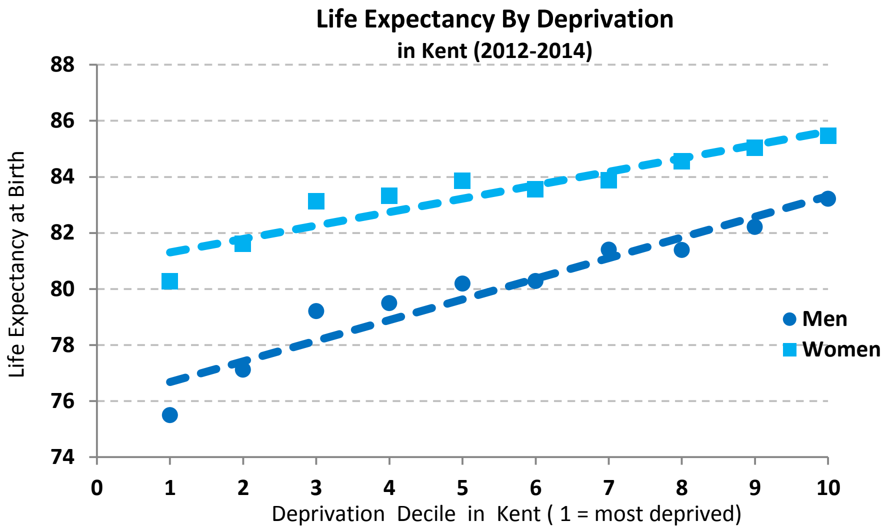


Figure 18 Life expectancy in Kent by deprivation decile

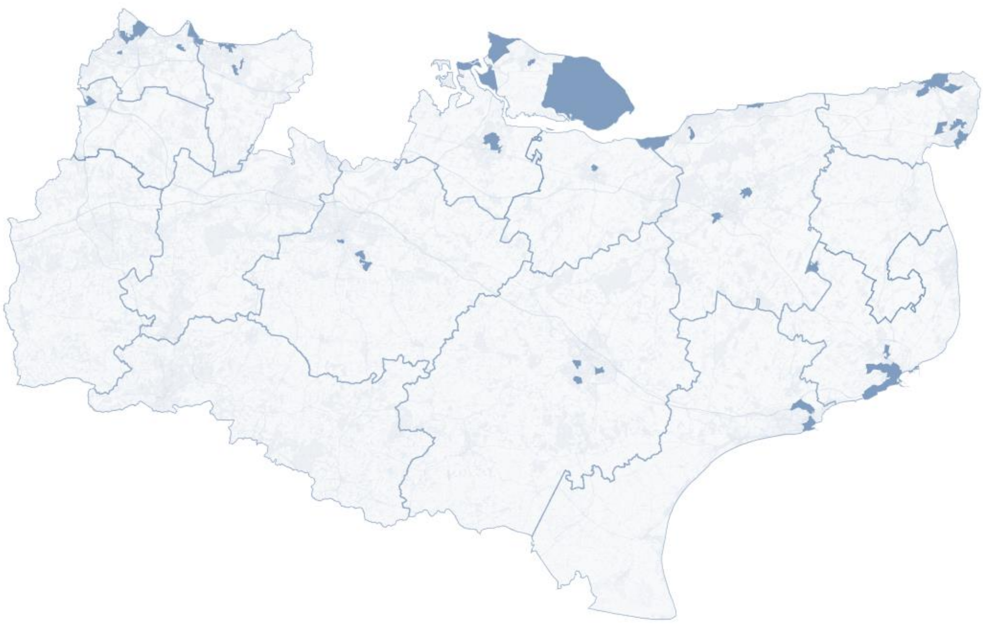


Figure 19 The 88 most deprived areas in Kent by IMD 2015 (Indices of Multiple Deprivation)

5 The Way Forward

Health needs in Kent are disproportionately greater in the most deprived populations, and we have mapped these populations geographically across Kent [Figure 19]. Closing the 'health gap' will require a faster improvement in health in these areas, so moving forward we will need to better engage with these communities at a local level to improve both wellbeing and health outcomes. Central to this approach is recognising the inherent skills, capabilities and talents of Kent's communities, empowering local people to own the solutions to developing thriving, healthy and sustainable communities. This approach requires action both within and outside of the health sector, and therefore will require collaborative partnerships between the County Council departments, District Councils, CCGs, healthcare providers, and community partners [Figure 20]. Tackling health inequalities in Kent is a task that will require the efforts of all: across multiple organisations and within communities themselves.

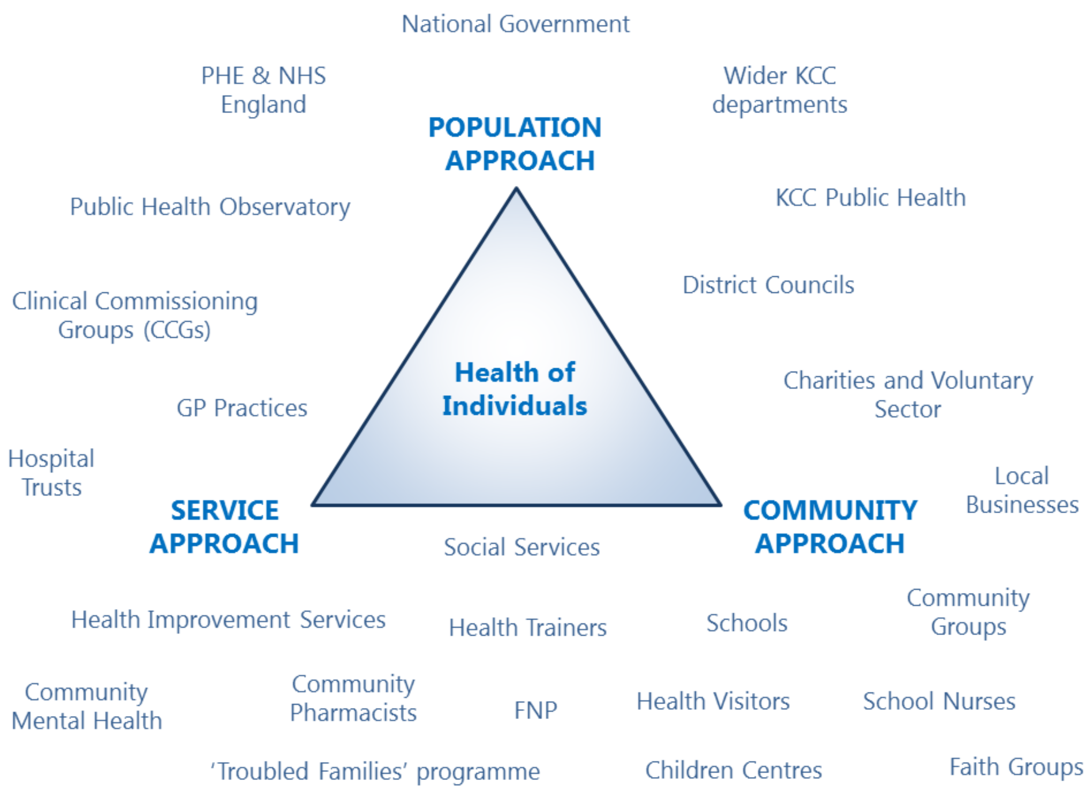


Figure 20 **Examples of stakeholders and partners that can impact on health**

Appendix 1: Health Inequality Indicators for Kent

Data from Public Health England Fingertips: http://fingertips.phe.org.uk/

Kent significantly better than national rate = Green
Kent significantly worse than national rate = Red
Kent not significantly different from national = Yellow

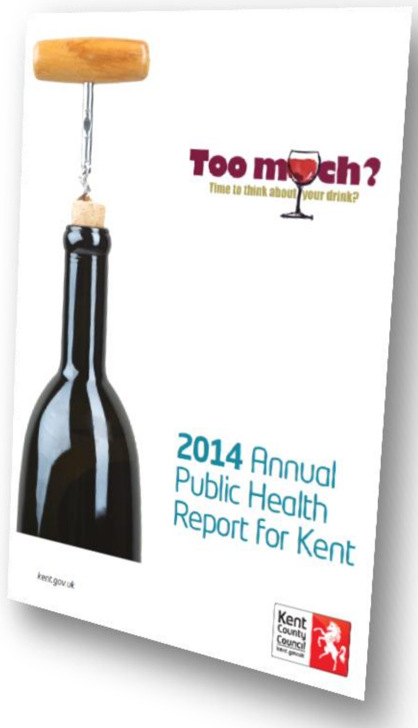
Lifecourse Stage	Indicator	Indicator Description	National (latest)	Kent (prior)	Kent (prior)	Kent (latest)	Kent Trend	Latest Data Period
INFANCY	Infant Mortality	Infant mortality (rate per 1000 live births)	4.0	-	3.2	2.9		2011-2013
	Smoking in Pregnancy	Smoking status at time of delivery (as % of maternities)	11.4%	15.2%	13.0%	12.6%		2014/15
	Breast Feeding	Breast feeding initiation (as % of maternities)	74.3%	72.1%	71.3%	71.3%		2014/15
	Teen pregnancy	Under 18 Conceptions (rate per 1,000 females aged 15-17)	22.8	24.3	22.9	22.2		2014
	Immunisations	Population vaccination coverage - MMR for 2 doses by 5 years of age (%)	88.6%	92.2%	87.1%	82.4%		2014/15
	Childhood Development	School readiness: % of children achieving a good level of development at the end of reception	66.3%	63.4%	68.5%	72.9%		2014/15
	Childhood Development (FSM)	School readiness: % of children with FSM status achieving a good level of development at the end o	51.2%	47.7%	51.8%	58.8%		2014/15
	Childhood Obesity (YR)	Overweight children (4-5 years) (% of children overweight or obese)	21.9%	21.7%	20.8%	22.5%		2014/15
CHILDHOOD	Childhood Obesity (Y6)	Overweight children (10-11 years) (% of children overweight or obese)	33.2%	32.6%	32.7%	32.8%		2014/15
	Childhood Poverty	Childhood Poverty (% of children under 16 in low income families)	18.6%	18.3%	17.6%	17.3%		2013
	Education (attendance)	Pupil Absence (% half days missed due to unauthorised/authorised absence 5-15yr olds)	4.51%	5.27%	5.30%	4.70%		2013/14
	Education (attainment)	GCSE Attainment (% achieving 5 good GCSEs A*-C including English and Maths)	56.8%	-	-	58.0%	-	2013/14
	Education (attainment)	16-18 year olds not in education, employment or training - NEET (%)	4.7%	6.4%	5.8%	4.7%		2014
	Childhood smoking	Percentage of current smokers - age 15	8.2%	-	-	10.5%	-	2014/15
	Childhood alcohol	Percentage of regular drinkers - age 15	6.2%	-	-	6.1%	-	2014/15
	Childhood wellbeing	Childhood wellbeing (percentage reporting low life satisfaction age 15)	13.7%	-	-	13.4%	-	2014/15
	Childhood mental health	Child admissions for mental health - per 100,000 aged 0-17 years	87.4	150.2	117.5	84.4		2014/15
	Looked-after children	Looked After Children - rate per 10,000 under-18 yrs population	60.0	56.0	56.3	57.0		2014/15
	Childhood injuries	Hospital admission caused by injuries in children (aged 0-14 years) per 10,000 population	112.2	111.0	95.3	100.1		2013/14
	Young people drug-use	Hospital admissions due to substance misuse (aged 15 - 24) ASR per 100,000	88.8	79.8	96.1	104.9		2012/13-14/1
	Young people self-harm	Hospital admissions as a result of self-harm (aged 15 - 24) ASR per 100,000	398.8	360.5	411.7	372.5		2014/15
	Young people offences	First time entrants to the youth justice system, rate of 10-17 year olds per 100,000 population	409	583	515	449		2014
ADULTS	Unemployment	Unemployment (% of working age population)	6.2%	-	7.4%	5.4%		2014
	Unemployment	Longterm Unemployment (per 1000 of working age population)	7.1	7.3	7.7	5.6		2014
	Employment Gap (LD)	Gap in employment rate between those with a learning disability and the overall employment rate	66.9%	65.2%	66.3%	65.0%		2014/15
	Employment Gap (MH)	Gap in employment rate between those in secondary mental health services and the overall emplyr	66.1%	64.0%	66.5%	68.3%		2014/15
	LD support & independence	Adults with a learning disability who live in stable and appropriate accomodation (%)	73.3%	70.1%	70.0%	72.4%		2014/15
	MH support & independence	Percentage of adults in contact with secondary mental health services in stable/appropriate accomc	59.7%	81.5%	77.6%	75.3%		2014/15
	Homelessness	Statutory Homelessness Acceptances (per 1000 households)	2.4	1.8	1.5	1.9		2014/15
	Domestic Abuse	Domestic Abuse (18+ years) recorded police incidents per 1000 population	18.8	16.4	16.9	17.3		2012/13
	Violent Crime	Violent crime (violence offences, crude rate per 1000 population)	13.5	10.7%	14.3	15.6		2014/15
	Healthy Eating	Proportion of population meeting the recommended '5-a day'	53.5%	-	-	56.2%	-	2014
	Healthy Weight	Excess weight: excess weight in adults	63.8%	-	-	64.6%	-	2012
	Physical Activity	Physical Inactivity (<30mins per week of moderate activity)	27.7%	27.5%	26.8%	28.4%		2014
	Green Space	Utilisation of outdoor space for exercise/health reasons (%)	17.1%	13.4%	10.7%	12.1%		2013/14
	Smoking	Smoking prevalence in adults (%) (from integrated household survey)	18.0%	20.9%	19.0%	19.1%		2014
	Smoking	Quit rate from Stop Smoking Services (%)	51.0%	-	52.1%	54.0%		2014/15
	Alcohol	Admission episodes for alcohol-related conditions (Broad) (ASR per 100,000)	2111	1602	1625	1695		2013/14
	Wellbeing	Self-reported well-being: % of people with a low happiness score	9.0%	9.90%	9.0%	10.1%		2014/15
	Depression	Adults with depression known to GPs (QOF prevalence)	6.5%	-	-	6.4%	-	2013/14
	Road Injuries	Killed and seriously injured on roads, crude rate per 100,000	39.3	36.1	36.9	39.6		2012-14
ELDERLY	Fuel Poverty	Fuel Poverty - households that experience fuel poverty (%) (low income, high cost methodology)	10.4%	9.0%	8.5%	8.6%		2013
	Winter Deaths	Excess winter deaths index (single year, all ages/persons)	11.6	15.2	21.8	13.8		2013/14
	Flu Vaccination	Population vaccination coverage - Flu (aged 65+) %	72.7%	71.4%	71.1%	70.9%		2014/15
	Falls	Injuries due to falls in people aged 65 and over (ASR per 100,000)	2125	2096	2224	2201		2014/15
	Hip Fractures	Hip Fractures in people aged 65 and over (ASR per 100,000)	571	544	581	598		2014/15
	Readmissions	Emergency readmissions within 30 days of discharge from hospital (Persons)	11.8	11.5	11.7	11.9		2011/12
	Health Checks	Cumulative percentage of the eligible population aged 40-74 who received an NHS Health check	18.6%	-	-	17.4%	-	13/14-2014/
	Cancer Screening (Breast)	Cancer Screening Coverage - Breast Cancer - % of eligible women screened in prior 3 years	75.4%	78.2%	77.6%	77.0%		2015
	Cancer Screening (Cervical)	Cancer Screening Coverage - Cervical Cancer - % of eligible women screened in prior 3.5 or 5.5 years	73.5%	77.2%	77.1%	77.1%		2015
	Cancer Screening (Bowel)	Cancer screning coverage - bowel cancer - % of eligible people screened in previous 2.5 years	57.1%	-	-	58.1%	-	2015
	End of Life Planning	Percentage of deaths that occur in Usual Place of Residence	44.7%	47.0%	45.4%	46.2%		2014
MORTALITY	Premature Mortality	Premature mortality from all causes (ASR per 100,000)	337	-	322	318		2012-2014
	Premature Mortality (cardio)	Under 75 mortality rate from cardiovascular disease considered preventable (ASR per 100,000)	49.2	52.3	49.3	46.0		2012-2014
	Premature Mortality (resp)	Under 75 mortality rate from respiratory disease considered preventable (ASR per 100,000)	17.8	16.6	16.7	16.5		2012-2014
	Premature Mortality (cancer)	Under 75 mortality rate from cancer considered preventable (ASR per 100,000)	83	81.5	79.3	78.4		2012-2014
	Premature Mortality (liver)	Under 75 mortality rate from liver disease considered preventable (ASR per 100,000)	15.7	12.4	13.2	13.7		2012-2014
	Air-pollution-related Mortality	Fraction of mortality attributable to air pollution (PM2.5) (% of all age all cause mortality)	5.3%	5.4%	5.0%	5.4%		2013
	Communicable Disease Mortality	Mortality from communicable disease (ASR per 100,000)	63.2	72.6	69.3	64.4		2010-2012
	Smoking-related Mortality	Smoking-related deaths (ASR pr 100,000)	274.8	276.6	272.6	266.7		2012-2014
	Alcohol-related Mortality	Alcohol-related mortality (ASR per 100,000)	45.5	43.4	44.8	42.4		2014
	Suicide	Suicide age-standardised rate per 100,000 (3 year average)	8.9	8.1	9.2	10.2		2012-14
	Preventable Mortality	Mortality rate from causes considered preventable	182.7	176.0	172.5	169.8		2012-2014
	Healthy Life Expectancy (male)	Health life expectancy at birth - years expected in good health (males)	63.3	63.6	63.5	62.8		2011-2013
	Helathy Life Expectancy (female)	Health life expectancy at birth - years expected in good health (female)	63.9	65.5	66.0	66.4		2011-2013
	Life Expectancy (male)	Life expectancy at birth - years (male)	79.5	79.9	79.9	80.1		2012-2014
	Life Expectancy (female)	Life expectancy at birth - years (female)	83.2	83.4	83.6	83.6		2012-2014
	Life Expectancy Gap (males)	Slope index of inequality in life expectancy at birth based on local deprivation deciles - years (male:	9.2	7.1	7.1	7.4		2012-2014
	Life Expectancy Gap (females)	Slope index of inequality in life expectancy at birth based on local deprivation deciles - years (fema	7.0	4.8	5.1	4.4		2012-2014

Appendix 2: Progress on Alcohol Strategy

Last year's Public Health Annual Report addressed the topic of alcohol. Good progress has been made towards achieving the aims within the six pledges of the Kent alcohol strategy for 2014-16. For example we aimed to screen 9% of the population by the end of 2016 and offer advice on reducing alcohol related harm. By the start of 2016, we had screened 11% and expect this to increase throughout 2016.

Each district now has a local alcohol action plan to tackle alcohol-harms in their communities. These plans link together with other partnership groups such as Community Safety Partnerships and Community Alcohol Partnerships to tackle alcohol related harm in the community. The good work of Kent Community Alcohol Partnerships has been highlighted by two Ministerial visits in north Kent during 2015. A web-based screening and advice tool, 'Know Your Score', was launched in January 2016. This is proving very popular – over 2500 people took the test and received advice in the first week it was launched! There has been fewer hospital admissions for the under 18s and work continues to reverse the increasing trends for alcohol-related illness and mortality in the Kent population.

Pledge	Action
Improve prevention and identification	We aim to screen 9% of the Kent population by the end of 2016 with Identification and Brief Advice (IBA) We will increase the number of partner organisations (or public service staff including community and voluntary groups) trained to conduct IBAs
Improve the quality of treatment	We will increase the number of people successfully completing alcohol treatment
Coordinate enforcement and responsibility	We will increase the number of Community Alcohol Partnerships in Kent, working closely with the Community Safety Partnerships. We aim to increase the number of Community Alcohol Partnerships in Kent
Tailor the plan to local communities	Each local authority area will receive an updated substance misuse needs assessment and detailed information on alcohol use trends for their area to help them develop a local Alcohol Action Plan
Target vulnerable groups and tackle health inequalities	We will work with partners such as sexual health services providers and housing associations to target support at vulnerable people
Protect children and young people	We will continue to provide education and treatment services to children and young people We aim to reduce alcohol related hospital admissions for under 18 year olds



New Alcohol Guidelines

- Both men and women are now advised not to regularly drink more than **14 units per week**.
- **Spread the units** throughout the week, limiting the amount you drink in one session, and include some **drink-free days** per week.
- If you are **pregnant** or planning pregnancy, the safest option is not to drink alcohol

Annual Public Health Report 2015

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BRIEFING PAPER

Number SN261, 13 February 2017

Aviation noise

By Louise Butcher

Contents:

Contents

Summary

This paper briefly looks at the impacts of aviation noise on those who live underneath flight paths and close to airports and explains the various measures put forward to tackle noise pollution, including flight restrictions and charges; better airspace design, and quieter aircraft.

Aviation noise is a source of constant annoyance to those who live under airport flight paths and for those subject to lower levels of disturbance caused by low flying smaller aircraft and helicopters. This form of noise pollution is explicitly excluded from general noise nuisance legislation.

The noise impacts of aviation on individuals and communities have been subject to a number of reports in recent years, some of which are summarised here. There have also been efforts to properly map and monitor noise, including the development of online live data sites which can be used by the public as well as industry.

Suggested measures to tackle noise vary from more controls and restrictions, to charges and better airspace and aircraft design. Some of these measures are exercised by international bodies and the UK Government while others are in the control of the industry – particular airports. There are also proposals for a new Independent Commission on Civil Aviation Noise (ICCAN), which would help develop airspace and noise policies and act as a guarantee to local people that their noise concerns would be heard.

Finally, for those affected there is the possibility of compensation, particularly in the form of funds for insulation; there will be specific schemes, possibly funded by a new noise charge, at Heathrow should it receive planning permission to build a third runway.

This paper deals with commercial airports and aircraft. For those affected by the separate issue of nuisance from low flying and recreational aircraft or helicopters, information can be found in HC Library briefing paper SN4059. Information on other aviation issues can be found on the Aviation Topical Page of the Parliament website.

1. What's the problem?

1.1 Noise impacts

In recent years, partially fuelled by the proposals for airport expansion in the South East of England, there has been renewed focus on the impacts of noise from aviation on those living beneath flight paths.

In January 2016 the Aviation Environment Federation (AEF) published a report stating that in the UK, over one million people are exposed to aircraft noise above levels recommended for the protection of health, and that around 460 schools are exposed to aircraft noise at levels around Heathrow "that can impede memory and learning in children", while around 600,000 people in the UK are exposed to average aircraft noise levels that risk regular sleep disturbance.[1]

In July 2016 the European Commission published a summary of a report looking at how living with aircraft noise affects wellbeing. It found that:

> Living within a daytime aircraft noise path (with noise at or above 55 decibels) … was negatively associated with all measures of subjective wellbeing: lower life satisfaction, lower sense of worthwhile, lower happiness, lower positive affect balance, and increased anxiety. The authors found consistently negative and significant results across all five variables. The researchers could also predict the effect on subjective wellbeing associated with each decibel increase in noise, which they say has potential for modelling the possible wellbeing impacts due to changes in aircraft noise.
>
> Although there were consistent negative impacts from daytime noise across all measures of wellbeing, the magnitude of these associations were small compared to other common drivers of wellbeing, such as unemployment, poor health and smoking (the negative effects of which are at least twice that of aviation noise).
>
> The researchers found no evidence that night-time noise affects subjective wellbeing. There is a possibility, however, not explored in the study, that the noise had a physiological effect on the individuals. Furthermore, the sample of residences affected by night-time noise at or above 50 decibels was 50% lower than for daytime noise, which may affect the significance of the results.[2]

This followed the publication of the final report of the Airports Commission, in July 2015. Alongside the report the Commission published a review looking at aircraft noise effects on health. It briefly summarised the strength of the evidence for aircraft noise effects on:

- cardiovascular health;
- sleep disturbance;
- annoyance;

[1] AEF, *Aircraft Noise and Public Health: the evidence is loud and clear*, 12 January 2016

[2] "How does living with aircraft noise affect wellbeing? A study of UK airports", *Science for Environment Policy*, Issue 462, 8 July 2016; based on: Lawton, R. and Fujiwara, D. (2016). *Living with aircraft noise: Airport proximity, aviation noise and subjective wellbeing in England*. Transportation Research Part D: Transport and Environment, 42: 104– 118. DOI: 10.1016/j.trd. 2015.11.002

- psychological well-being; and
- effects on children's cognition and learning

It also briefly discussed guidelines for environment noise exposure. Overall, it concluded that:

> The health effects of environmental noise are diverse, serious, and because of widespread exposure, very prevalent … For populations around airports, aircraft noise exposure can be chronic. Evidence is increasing to support preventive measures such as insulation, policy, guidelines, & limit values. Efforts to reduce exposure should primarily reduce annoyance, improve learning environments for children, and lower the prevalence of cardiovascular risk factors and cardiovascular disease …[3]

Data from the CAA published in 2014 showed that the top fifteen airports in the UK account for over one-third of the population affected by noise at the European level using standard measurements, with Heathrow accounting for more than a quarter.[4] The Airports Commission had previously published an aviation noise discussion paper in July 2013 which attempted to give comparative figures for those affected by aviation noise as opposed to other transport noise:

> The number of people deemed to be affected by transport noise will depend on the noise metric used […] However, to give a sense of the relative numbers affected from each mode, the strategic noise mapping that took place in England in 2006 estimated that 4.2 million people are exposed to road traffic noise of 65 decibels (dB) (LDEN) or more, and found that the corresponding figures for railways and aviation are 0.2m people and 0.07m people, respectively.[5]

1.2 Views on noise by those affected

In February 2017 the CAA published its survey of noise attitudes (SoNA).

This largely replaces the last large scale survey *Attitudes to Noise from Aviation Sources in England* (ANASE), which was published in 2007.[6] ANASE concluded that levels of annoyance reported by respondents increased with the sound level; people were concerned about noise at even low levels and particularly at night; and people were generally more annoyed at the same level of noise in this study than in similar work carried out in the early 1980s (possibly due to increased numbers of aircraft).

In late 2013 Ian Flindell & Associates and MVA Consultancy conducted a review of the ANASE study and its 1980s counterpart (ANIS) for the 2M Group of local authorities. It criticised policymakers' reliance on older

[3] Queen Mary University of London, for the Airports Commission, *Aircraft noise effects on health*, May 2015, p27
[4] CAA, *CAA Insight Note: Aviation Policy For The Environment*, 2014, p22
[5] Airports Commission, *Discussion Paper 05: Aviation Noise*, July 2013, para 2.6
[6] John Bates Services etc. for the DfT, *ANASE: Attitudes to Noise from Aviation Sources in England*, October 2007

data, the focus on 'the onset of significant annoyance' at 57 LAeq[7] and the belief "that communities below this noise exposure threshold are relatively unaffected by aircraft noise – despite the fact that many such residents say that they are".[8]

SoNA stated that its purpose was to:

- Obtain new and updated evidence on attitudes to aviation noise around airports in England, including the effects of aviation noise on annoyance, wellbeing and health;
- Obtain new and updated evidence on what influences attitudes to aviation noise, and how attitudes vary, particularly how attitudes vary with LAeq, but also other non-acoustic factors that may influence attitudes, such as location and time of day, and socio economic group of respondents;
- Examine whether the currently used measure of annoyance, LAeq, is the appropriate measure of annoyance for measuring the impact on people living around major airports;
- Consider the appropriateness of the policy threshold for significant community annoyance from aviation noise; and
- Provide baseline results that can be used for a programme of regular surveys of attitudes to aviation noise.[9]

Its main conclusions were as follows:

- **Mean annoyance score correlated well with average summer day noise exposure, LAeq,16h**. There was no evidence found to suggest that any of the other indicators Lden, N70 or N65 correlated better with annoyance than LAeq,16h. However, the study recognised that the concept of a time-averaged metric such as LAeq,16h and the fact that it is measured and reported on a logarithmic scale where a change of 3 dB representatives a doubling or halving of noise energy can be difficult to understand. It therefore recommended that greater use be made of Nx metrics "as supplemental indicators to help portray noise exposure, but recognising that evidence-based decisions should continue to use LAeq,16h";[10]
- **Mean annoyance score** and the likelihood of being highly annoyed were found to increase with increasing noise exposure (LAeq,16h). The relationship found was close to linear, though annoyance levels plateau at low exposure and do not reach zero annoyance;[11]
- **Noise exposure and reported annoyance were compared against self-reported health rating** (5 point scale) and the

[7] when a noise varies over time, the LAeq is the equivalent continuous sound which would contain the same sound energy as the time varying sound; in simple terms it as a type of average, where noisy events have a significant influence
[8] Ian Flindell & Associates and MVA Consultancy for 2M Group, *Understanding UK Community Annoyance with Aircraft Noise: ANASE Update Study*, September 2013, pi
[9] CAA, *Survey of noise attitudes 2014: Aircraft*, CAP 1506, 2 February 2017, p5
[10] ibid., p63
[11] ibid., p64

Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS), a measure of well-being. Poorer health ratings and lower SWEMWBS scores were found to be associated annoyance, but not with noise exposure;[12] and

- Evidence was found that **non-acoustic factors** such as noise sensitivity, approximated social grade, and expectations – both prior to moving to an area exposed to aircraft noise and in the future – influence reported aircraft noise annoyance and these non-acoustic factors may be as important as the noise exposure level. From the survey as a whole, 9% of respondents were estimated to be highly annoyed at an exposure level of 54 dB LAeq,16h.[13]

The AEF welcomed SoNA as "new evidence which reflects the findings of numerous other studies that people now have a lower tolerance of aircraft noise levels than in the past". In particular, on the question of whether the metrics employed to measure aircraft noise annoyance (specifically Leq) are appropriate, it said that:

> The study concluded that, compared with 'N' measures (the number of overflights at or above a given noise level), Leq has the best fit with reported annoyance. However, the 'N' measures may work more effectively for communicating noise to communities since it can be understood more intuitively.
>
> We welcome the recommendation that noise impacts should be considered and communicated using a range of metrics. 'Number above' metrics may be particularly relevant for night noise, since the overall mean noise level at night may be less relevant than the number of one-off incidents that are noisy enough to cause awakening.[14]

[12] ibid., p65
[13] ibid., pp65-6
[14] AEF press notice, "Lower threshold for noise annoyance CAA study finds", 8 February 2017

2. How is noise mapped & monitored?

It is as yet unclear what the impact of Brexit might be on noise management or on aviation policy more generally. More information can be found in HC Library briefing paper *Brexit: impact across policy areas*.

Airports covered by EU Directive 2002/49/EC relating to the assessment and management of environmental noise[15] must prepare noise action plans, based on previously generated noise maps (contours), and submit these for formal adoption by the Government.[16] In July 2013 the Government published new guidance for airports on drawing up their noise action plans. It stated that the plans must, amongst other things, be designed to manage noise issues and effects, including noise reduction if necessary and aim to preserve quiet areas in agglomerations.[17]

There are Noise and Track Keeping Working Groups at major airports such as Heathrow, and Stansted, to allow representatives of interested parties to consider noise and track keeping issues at the relevant airport.

London Heathrow, and other major airports, have a noise and track-keeping computer system which gathers information on both the noise made by aircraft operating to and from the airport and the actual track each aircraft makes.[18] In August 2016 HAHL announced that 50 new noise monitors would be added the airport's existing network.[19]

Over the past ten years major airports have partnered with technology companies to launch interactive aircraft noise websites available to the public.

Live noise tracking

WebTrak provides live tracking for:

- Heathrow, Stansted, Manchester, Southampton, Bournemouth and East Midlands airports

Casper provides live tracking for:

- Gatwick, Manchester and Birmingham airports

[15] information on environmental noise generally, including the provisions of this Directive, can be found in: Parliamentary Office of Science and Technology, *Environmental Noise (Postnote 338)*, July 2009; this is a devolved issue - the Directive was implemented by the *Environmental Noise (England) Regulations 2006* (SI 2006/2238); *Environmental Noise (Wales) Regulations 2006* (SI 2006/2629); *Environmental Noise (Scotland) Regulations 2006* (SSI 2006/465); and *Environmental Noise Regulations (Northern Ireland) 2006* (NISR 2006/387)

[16] DfT, *Night Flying Restrictions at Heathrow, Gatwick and Stansted Stage 1 Consultation*, January 2013, p14; the noise map for London Heathrow is available on the Defra noise mapping website [accessed 19 October 2016]

[17] DEFRA, *Guidance for Airport Operators to produce noise action plans under the terms of the Environmental Noise (England) Regulations 2006 (as amended)*, July 2013, box 1, p4

[18] more technical information about the system is available in: CAA, *Validating the CAA aircraft noise model with noise measurements*, 2001

[19] HAHL press notice, "50 new noise monitors installed around Heathrow", 17 August 2016

The Environmental Research and Consultancy Department (ERCD) of the Civil Aviation Authority (CAA) estimates the noise exposures around the designated airports (Heathrow, Gatwick and Stansted) on behalf of the Department for Transport. The magnitude and extent of the aircraft noise around these airports are depicted on maps by contours of constant aircraft noise index (Leq) values. The contours are generated by a computer model validated with noise measurements, which calculates the emissions and propagation of noise from arriving and departing air traffic. The most recent data covers 2015.[20]

The Department for Transport also publishes noise exposure contour reports on Ordnance Survey (OS) maps produced by the CAA for Heathrow, Gatwick and Stansted airports. The most recent data covers 2015.[21]

[20] DfT, *Noise exposure contours around London airports*, 12 January 2017
[21] DfT, *Noise exposure contours on Ordnance Survey maps*, 12 January 2017

3. Measures to tackle noise

Aviation noise is generated mainly by actual aircraft and by airport ground operations, including ground transportation. However, noise from ground operations is largely confined to the airport site and the immediate vicinity, usually along well-established transport corridors where there are limited numbers of residential homes (i.e. along motorways and major A roads). Noise from aircraft is more pervasive and can be heard from a greater distance.

When looking at measures for tackling noise pollution from aviation it is sometimes difficult to separate out those specifically aimed at airports, encompassing the wider array of operations including how aircraft use the airport, from those only aircraft owners and operators can tackle (i.e. in the design and manufacture of quieter aircraft).

The Coalition Government's policy on aviation noise is "to limit and, where possible, reduce the number of people in the UK significantly affected by aircraft noise, as part of a policy of sharing benefits of noise reduction with industry".[22]

3.1 Flight controls and restrictions

UK law

Section 79(6) of the *Environmental Protection Act 1990*, as amended, specifically exempts aircraft noise from the general noise nuisance controls which exist under that legislation. This is the case, irrespective of whether an airfield in question is small and unlicensed or a major UK airport.

The Secretary of State for Transport is responsible for policy generally on the control of civil aircraft noise under section 78 of the *Civil Aviation Act 1982*, as amended. These powers are devolved in Scotland to Scottish Ministers.[23] Under section 78(3) the relevant authority may "specify the maximum number of occasions on which aircraft of descriptions so specified may be permitted to take off or land" at airports so designated under section 80 of the same Act.

At present these controls apply only to **London Heathrow**, **Gatwick** and **Stansted** (the 'designated airports').

Generally, it should be noted that so long as the *Rules of the Air Regulations 2007* (SI 2007/734), as amended, are being observed, aircraft are protected from action in respect of trespass or nuisance under the 1982 Act.[24] Within controlled airspace, aircraft need air traffic control clearance, which gives air navigation service providers (ANSPs) some scope for exercising controls. Such controls are usually concerned with safety, but they also have to take account of noise requirements. Controlled airspace only extends around airports and

[22] DfT, *Aviation Policy Framework*, Cm 8584, 22 March 2013, para 3.12
[23] via section 12 of the *Civil Aviation Act 2006*
[24] the *Rules of the Air* are made under Part 10 (Article 249) of the *Air Navigation Order 2016* (SI 2016/765), and are similar to a Highway Code for the airspace over the UK

along air routes. Controlled airspace can go from ground level to 66,000 feet in some cases, and 'air routes' can have bases down to 3,500 ft. Outside controlled airspace, aircraft can go anywhere so long as they abide by the *Rules of the Air.*

The Government has powers under the 1982 Act to designate areas where aircraft are not allowed to fly, but this is usually done only on safety or security grounds, for instance over high security prisons or sensitive installations.

Except for the designated airports, the view of consecutive governments has been that noise at airports is essentially a local matter and best dealt with at local level. Most large airports have consultative committees and any changes in the rules are likely to be discussed with them.[25] In its March 2013 *Aviation Policy Framework* the Government said:

> … airports not currently designated for noise management purposes have powers to set noise controls … and the Government would like appropriate controls to be agreed locally. For example, local authorities will want to consider whether to set such controls as a planning condition on new airport development. Noise controls at the designated airports will provide examples for other airports to consider as appropriate. Airports should ensure that the effectiveness of their measures to tackle noise is reviewed on a regular basis. For airports required to produce Noise Action Plans under EU legislation, this should be done at least as often as the five-yearly review of these plans. Noise Action Plans and any other noise measures agreed locally should be proportionate to actual noise impacts.[26]

Night flights

At the designated airports of Heathrow, Gatwick and Stansted the relevant authority (the Secretary of State for Transport in the case of England and Wales, Scottish Minister in Scotland) can mitigate the problem by limiting the number of flights and the type of aircraft that fly into and out of airports during the early morning (from 2300 to 0700). These are generally referred to as 'night flights'.

The current regime expires in October 2017 and in January 2017 the Government published its proposals for new limits to operate between 2017 and 2022. The key points are:

- reducing the total noise quota at Heathrow Airport by at least 43% in the winter and 50% in the summer;
- reducing noise quotas at Gatwick by at least 17% in the winter and 21% in the summer;
- setting a strict cap at existing levels for the number of night flights from Heathrow and Gatwick; and
- ending exemptions for almost 1,700 night flights operating out of Stansted by including these in the new cap, setting a strict limit which the airport cannot exceed.

For more information see: HC Library briefing paper SN1252, *Night flights at Heathrow, Gatwick & Stansted*.

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[25] the DfT published an updated industry Code of Practice in November 2006, designed to limit noise impacts on local areas, see: DfT, *Noise from Arriving Aircraft: An Industry Code of Practice* (2nd ed.), November 2006

[26] op cit., *Aviation Policy Framework*, para 3.11

EU law

As indicated above, it is as yet unclear what the impact of Brexit might be on noise management or on aviation policy more generally.

That said, in terms of European law, Directive 2002/30/EC, on the introduction of noise-related operating restrictions at Community airports, was adopted in March 2002. It did not require airports to take action to counter noise pollution, but it did set out a process that must be followed should any action be contemplated. The Directive was implemented in the UK by the *Aerodromes (Noise Restrictions) (Rules and Procedures) Regulations 2003* (SI 2003/1742), which came into force in August 2003. The Directive was replaced by Regulation (EU) No 598/2014 from 13 June 2016.

The 2003 Regulations state that when plans to deal with noise problems at major airports are being drawn up, the following will have to be taken into account:

- use of modern, quieter aeroplanes;
- use of procedures to reduce operational noise (optimising use of traffic management procedures);
- effect of land-use planning and management policies in preventing or limiting noise sensitive development around airports; and
- restrictions or possibly bans on aircraft.

The Regulations apply to city airports (listed in Schedule 1 to the Regulations) and to other civil airports within the UK which have more than 50,000 take-offs or landings of civil subsonic jet aeroplanes per calendar year (based on the average of the last three calendar years before the application of the Regulations to the airport in question).[27] The 'competent authority' is the airport operator, except where the airport is designated under section 78 of the 1982 Act. In such cases the competent authority is the Secretary of State.

3.2 Charges for noise pollution

At the moment there are various powers set out in the *Civil Aviation Act 1982*, as amended, which allow airports to make charges to airlines and to fine them for failing to comply with relevant conditions.

Specifically, section 38 of the 1982 Act gives licensed aerodrome authorities the power to fix their charges in relation to aircraft noise, or to the extent or nature of inconvenience resulting from such noise. The aim of this section is to encourage the use of quieter aircraft and diminish inconvenience from aircraft noise. An aerodrome authority may charge aircraft operators for use of the aerodrome by reference to the emissions from an aircraft (as well as to the noise produced).

[27] for example, London Heathrow, Gatwick, Stansted, Luton and City, Manchester, Edinburgh, Glasgow, Birmingham and Belfast

For regulated airports (i.e. Heathrow, Gatwick and Stansted) sections 78, 78A and 78B of the 1982 Act, as amended by the *Civil Aviation Act 2006*, confer on the manager of a designated aerodrome a power to levy financial penalties on an aircraft operator in respect of any breach by that aircraft operator of noise abatement requirements imposed by the Secretary of State and require the aerodrome manager to make payments, equal to the amount of penalties received, for the benefit of persons who live in the area in which the aerodrome is situated.

In October 2013 the CAA published a report recommending that airports should use their landing charges to offer better incentives for airlines to operate cleaner and quieter flights.[28] It found that the monetary incentives designed to encourage airlines to use the quietest aircraft vary from airport to airport and that while designated airports levy landing charges, non-designated airports tend to levy other surcharges and penalties which, although they do serve a noise management role, are not strictly speaking noise-related landing charges. It recommended that noise charging categories be better defined and target the full range of aircraft with higher charges at night.[29] The CAA published further recommendations in May 2014 reiterating its call for airports to structure their landing charges to incentivise airlines to operate cleaner, quieter flights.[30]

3.3 Curtailing airport expansion

Arguably the easiest way to reduce noise impacts from aviation is to close airports or at least to restrict their growth. In terms of reducing impacts on people on the ground, a further solution might be the re-siting of existing airports or construction of new airports away from centres of urban population. This was one of the arguments put forward for constraining expansion at Heathrow and for expanding Gatwick or building a new airport in the Thames Estuary. Others take the view that there is a fundamental conflict between increasing aviation capacity and limiting or reducing noise impacts.

On the one side of the debate Sustainable Aviation, funded by the aviation industry, argued in its Noise Action Plan that aircraft innovations and engine technology, operational advancements and better land-use planning offered the potential to reduce UK aviation noise output by 2050 compared to 2010, despite a forecast growth in flights.[31] This would leave room for considerable expansion of the UK's aviation capacity. On the other hand, the Aviation Environment Federation (AEF), an NGO supported by environmental groups, has

[28] CAA press notice, "CAA calls on airports to use landing charges to encourage cleaner, quieter flights", 15 October 2013
[29] CAA, *Environmental charging – Review of impact of noise and NOx landing charges*, CAP 1119, October 2013, pp50 & 53
[30] CAA press notice, "CAA urges UK aviation to improve noise performance and do more to engage communities", 29 May 2014
[31] Sustainable Aviation, *Noise Road Map*, 23 April 2013

argued that expansion schemes should meet stringent noise criteria in order to be approved.[32]

The Government is currently proposing that as a condition of its planning consent for a third runway, Heathrow would have to commit to "mitigate the noise impacts which could result from a new runway. Measures will include new binding noise performance targets to encourage the use of quieter aircraft, and continuing to alternate the airport's runways to provide local communities with predictable periods free from noise". It also stated that it agrees with Sustainable Aviation that "predicted improvements in aircraft technology and procedures should mean that, with or without expansion, fewer people than today would be affected by noise".[33]

The main campaign group for residents affected by Heathrow, Hacan, is dubious. It stated that a new runway would bring a "considerable number of new people" under a flight path for a first time, that those communities which currently enjoy a half day's break from the noise "are likely to find that reduced to a third of a day" and that a third runway "is expected to increase the number of planes using Heathrow by around 250,000 a year". It concludes: "quieter planes and improved operation practices cannot wish that number away".[34]

3.4 Independent Commission on Civil Aviation Noise (ICCAN)

The final report of the Airports Commission into airport capacity, published in July 2015, said that an Independent Aviation Noise Authority (IANA) "should be established with a statutory right to be consulted on flight paths and other operating procedures. The authority should be given statutory consultee status and a formal role in monitoring and quality assuring all processes and functions which have an impact on aircraft noise, and in advising central and local Government and the CAA on such issues".[35]

Further, the Commission recommended that the Government introduce a noise charge or levy to "incentivise airports to reduce noise and ensure that they make an appropriate contribution to local communities".[36] IANA should "advise on the exact design and weighting of a charge and provide guidance or direction on how funds raised are most fairly allocated with regard to noise impacts. This may include an assessment of pre-existing arrangements at different airports. Local people should be able to see clearly how funds are used in their local areas and should have real influence over how money is spent".[37]

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32 AEF, *Evidence to the Airports Commission: Comments on Discussion Paper 05: Aviation Noise*, September 2013, para 1.2

33 DfT, *Consultation on Draft Airports National Policy Statement: new runway capacity and infrastructure at airports in the south-east of England*, 2 February 2017, p31

34 Hacan, *National Policy Statement: Briefing from HACAN*, 2 February 2017

35 Airports Commission, *Final Report*, 1 July 2015, p32

36 ibid., p292

37 ibid., p293

The Commission listed a number of further activities which it believed IANA could undertake.[38]

In its consultation on future airspace policy, published on 2 February, the DfT put forward its proposals for what it calls an Independent Commission on Civil Aviation Noise (ICCAN), basically its version of IANA. The DfT's 'success criteria' for ICCAN were set out as follows:

- It establishes a credible and authoritative voice on aviation noise issues;
- Communities have and feel they have a greater stake in any process which proposes to make noise changes;
- Processes which change aviation noise impacts better and more transparently balance the needs of all parties, thereby making these processes fairer and less adversarial;
- Greater public confidence in the noise data published by the aviation industry and in the impartiality of the airspace change process;
- Industry is challenged to enhance its approach where necessary on assessing and mitigating noise impacts and engaging with communities;
- Improved relations and trust underpin local decision making on noise controls; and
- The SofS is effectively supported in his role with regards to noise within strategically significant decisions[39]

ICCAN's detailed role in airspace change and planning and ongoing noise management, as set out in the paper, is summarised below.

On **airspace change**:

- Respond to all formal airspace consultations to advise that the most appropriate and best available noise mitigations have been considered appropriately. ICCAN would not choose between different route options. This is because there would be other non-noise factors at play such as safety and efficiency, and these also need to be taken into account when deciding on a best option.
- Where a change sponsor has deviated from ICCAN advice on any noise management techniques, the sponsor should describe their reasoning behind their decision not to follow the advice. The CAA would take into account any relevant ICCAN advice in its environmental assessment, and in doing so, can decide on whether a change sponsor's reasoning for deviating from the advice is justified.
- If … an airspace change decision [were] called-in by the Secretary of State … ICCAN would give any expert advice required.
- Consulted as part of the CAA's Post-Implementation Review process following a change taking place e.g. to assess the outcomes of any noise mitigations.[40]

[38] ibid., p304
[39] DfT, *UK Airspace Policy: A framework for balanced decisions: on the design and use of airspace*, CM 9397, 2 February 2017, pp54-55
[40] ibid., p56

And on **planning and ongoing noise management**:

- Advise airports and relevant competent authorities in the process to agree operating restrictions including advising the competent authority whether they consider the ICAO balanced approach to have been followed.
- As an example, ICCAN should have a role in advising on the design of noise envelopes … where one is being developed, such as has been suggested at Heathrow for the proposed new northwest runway.
- Advise local authorities when requested when they are considering noise implications of an airport's planning application.
- Provide input to planning inquiries relating to airport infrastructure as appropriate.[41]

The Government's lead option is to establish ICCAN as an independent body within the CAA. However, it recognises that ICCAN should be able to function independently from the CAA "if it is to be successful in building trust" and therefore proposes to direct the CAA under legislative powers to establish ICCAN as a separate legal entity. The Secretary of State would set Terms of Reference, establish the appointment process for the Commissioner and Board members of ICCAN, and agree its funding. To 'maintain credibility', it "would be up to ICCAN's Board to set a yearly work programme based on the Terms of Reference and its agreed funding". One of the Board members would be a senior official from the Department for Transport with a limited remit to ensure that ICCAN's work programme remained consistent with the Terms of Reference. ICCAN's governance would "include total functional separation between it and the CAA: they would work on separate work streams with no crossover".[42]

The paper also states that ICCAN should be "funded publicly *in the first instance*".[43] It is unclear whether this means that at some future date such a body might be sold off or funded in some way by the aviation industry.

3.5 Airspace design and Air Navigation Routes

UK airspace contains a network of corridors, or airways. These are usually ten miles wide and reach up to a typical height of 24,000 feet from a typical base of between 5,000 and 7,000 feet (however, as noted above they can stretch between 3,500 and 66,000 feet). They mainly link busy areas of airspace known as terminal control areas, which are normally above major airports. At a lower level, control zones are established around each airport. The area above 24,500 feet is known as upper airspace. All of these airways are designated "controlled airspace". Aircraft fly in them under the supervision of air

[41] ibid., p57
[42] ibid., p58
[43] ibid., p59 [emphasis added]

traffic controllers and pilots are required to file a flight plan for each journey, containing details such as destination, route, timing and height.

Throughout Europe there is a move to restructure European airspace, add capacity, improve safety and increase the overall efficiency of the European air transport network through the Single European Sky (SES) project.

The UK and Ireland is planning to meet the SES requirements through the Future Airspace Strategy (FAS) which sets out a plan to modernise airspace by 2020.

The biggest changes in the UK are likely to be in the south east of England (whose airspace was designed over 40 years ago) where London's five big airports and many smaller aerodromes create some of the world's busiest and most complex skies.

There have been airspace trials at airports across the south east, including Heathrow, London City and Stansted as part of the London Airspace Management Programme (LAMP). The first part of LAMP affecting London City Airport and the south coast was implemented in February 2016. In addition, Gatwick has undertaken a number of trials of standalone technology/procedure enablers, such as ADNID and routes 2&4. These were particularly controversial with local residents and the proposed changes around the airport were postponed.

On 2 February 2017 the DfT published a consultation on modernising the UK's airspace. This contained a number of proposals about dealing with the noise from overhead flights. Overall the Government is proposing:

- greater transparency in decision making and the way noise is handled;
- increased focus on engagement and locally-informed solutions;
- improvements to the evidence base which informs how airspace decisions are made, particularly evidence on the noise impacts; and
- clarity and consistency in the level at which decisions are made, and why.[44]

In addition to a new Independent Commission on Civil Aviation Noise (see above), this would involve the following:

- **Assessing adverse effects of aviation noise** – DfT to provide further guidance on its aviation noise policy in order to be clear about how it should inform decisions on airspace design and use. The policy should be interpreted to mean that the number of people experiencing adverse effects as a result of aviation noise should be limited and, where possible, reduced. Adverse effects would be considered to be those related to health and quality of life: 51 dB LAeq 16hr should be regarded as the LOAEL [Lowest

[44] op cit., *UK Airspace Policy: A framework for balanced decisions: on the design and use of airspace*, p68

Observed Adverse Effect Level] for daytime noise and 45 dB Lnight for night time noise;[45]

- **Assessing the frequency of aircraft noise occurrences** – To take account of people who may be significantly affected by aviation noise at levels that do not exceed the LOAEL, DfT intends to supplement the risk-based approach with guidance on metrics which can be used to assess the frequency of noise events;[46]

- **The Balanced Approach[47] and noise management** – DfT proposes two routes for decisions on operating restrictions being taken within the planning process. In most cases for both routes, the airport itself would be expected to lead the development and consultation on any proposed restrictions, with the competent authority ensuring the correct process is followed. In England and Wales[48] the SofS would be appointed competent authority for all operating restrictions delivered through the planning process in the case of Nationally Significant Infrastructure Projects (NSIPs), as well as any local planning decisions that are called-in by the Secretary of State while all other planning-related operating restrictions would be decided by the relevant local authority;[49] and

- **Other noise controls at the designated airports** – In order to allow the designated airports to manage noise in the way that best reflects the issues faced by their communities, DfT proposes that responsibility for setting other types of noise controls is transferred to the airport. They could then be agreed locally or decided through the planning process or airspace change processes. DfT would also transfer the ownership of Noise Preferential Routes (NPRs) to the designated airports, which would also be required to publish data on their departure routes and track keeping performance. To be clear, designated airports have been publishing this data for decades, this would be a change to the basis on which it's published. [50]

The consultation closes on 25 May 2017.

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[45] ibid., p52
[46] ibid., 52
[47] this refers to ICAO's Balanced Approach, which lays down a common framework for managing noise
[48] this would be a devolved matter in Scotland and Northern Ireland
[49] op cit., *UK Airspace Policy: A framework for balanced decisions: on the design and use of airspace*, p64
[50] Ibid., pp65-6

3.6 Aircraft design

A Noise certification database NoisedB was developed in 2006 by the French DGCA under the aegis of ICAO. The database is intended to be a general source of information to the public on certification noise levels for each aircraft type.

One of the main ways of reducing aircraft noise is by limiting that noise at source.[51] International agreement is essential in this respect because of the world-wide nature of the aviation industry.

The International Civil Aviation Organization (ICAO) was established in 1944. Part of its role is to reduce aviation noise; much of its effort in this area has been directed to reducing noise at source – i.e. in aircraft specification. Aeroplanes and helicopters built today are required to meet the noise certification standards adopted by the Council of ICAO. These are contained in Annex 16 to the Convention on International Civil Aviation (the 'Chicago Convention'), while practical guidance to certificating authorities on implementation of the technical procedures of Annex 16 is contained in the *Environmental Technical Manual on the use of Procedures in the Noise Certification of Aircraft*.[52]

The categorisation of aircraft under Annex 16 is described on the ICAO website:

> The first generation of jet-powered aeroplanes was not covered by Annex 16 and these are consequently referred to as non-noise certificated (NNC) aeroplanes (e.g. Boeing 707 and Douglas DC-8). The initial standards for jet-powered aircraft designed before 1977 were included in Chapter 2 of Annex 16. The Boeing 727 and the Douglas DC-9 are examples of aircraft covered by Chapter 2. Subsequently, newer aircraft were required to meet the stricter standards contained in Chapter 3 of the Annex. The Boeing 737-300/400, Boeing 767 and Airbus A319 are examples of "Chapter 3" aircraft types. In June 2001, on the basis of recommendations made by the fifth meeting of the Committee on Aviation Environmental Protection (CAEP/5), the Council adopted a new Chapter 4 noise standard, more stringent than that contained in Chapter 3. Starting 1 January 2006, the new standard became applicable to newly certificated aeroplanes and to Chapter 3 aeroplanes for which re-certification to Chapter 4 is requested. Most recently, CAEP/8 in February 2010 requested the noise technical group to review and analyze certification noise levels for subsonic jet and heavy propeller driven-driven aeroplanes and, based on the analysis, develop a range of increased stringency options.[53]

According to the CAA, modern aircraft are typically 75 per cent quieter than jet aircraft used in the 1960s.[54] As indicated above, aircraft manufactured since 2006 must meet the requirements of Chapter 4,

[51] for some information on smaller scale aircraft improvements to e.g. engines and wings, see EurActiv, "Winging it: EU researchers look for novel ways to cut aircraft noise", 21 June 2013 and "Heavy metal thunder: Aircraft grow quieter as rock drones on", 17 June 2013

[52] Annex 16 and other international requirements were transposed into UK law by the *Aeroplane Noise Regulations 1999* (SI 1999/1452) and the *Air Navigation (Environmental Standards) Order 2002* (SI 2002/798)

[53] a slightly longer outline of the contents of Annex 16 is given in: ICAO, Aircraft Noise Certification (presentation to the Noise Certification Workshop), 20-21 October 2004

[54] CAA, *Aircraft Noise and Emissions* (Environmental Information Sheet no. 10), 2014; for a neat pictorial representation see: Airports Commission, *Interim Report*, December 2013, fig 2.6, p39

which was set at 10 decibels below that of Chapter 3. Campaigners argued that this was not enough:

> A new standard for aircraft noise, Chapter 4, [came] into force on 1 January 2006. However, the new standard is very weak and already met by 98% of aircraft currently in-production. It will improve the current standard by a little over 3dB, on average, at each measurement point. The industry's aspirational target is to develop an aircraft that reduces perceived aircraft noise by 50% by 2020 compared to 2000 (ACARE, 2000). Even if this demanding target can be met, it will take several years with its gradual introduction to the fleet before the benefits are felt. Moreover, such improvements are not sure to counter the effects of increasing traffic.[55]

A new standard will be introduced from the end of 2017 (see below).

When the Chapter 3 standard was introduced in 2002[56] it led to the elimination of most of the noisier planes meeting Chapter 2 noise standards from European skies. The phasing out of noisier Chapter 2 aircraft was governed by certain conditions agreed with ICAO, among which were exemptions to operators in developing nations, for specific aircraft. The cumulative effect of these changes is debatable as reductions in noise generated by individual aircraft have to be balanced against increases in the numbers of aircraft in operation, particularly around larger airports that have continued to expand – even when they have not been able to do so geographically with new runways.

Current noise and emissions standards for UK-registered aircraft are set out in *Air Navigation (Environmental Standards For Non-EASA Aircraft) Order 2008* (SI 2008/3133) and European Regulation 216/2008/EC (the 'Basic Regulation'), as amended. The Basic EASA Regulation established the European Aviation Safety Agency (EASA), set out essential requirements for environmental protection and provides for the making of implementing rules in support of those essential requirements.

The aircraft which are not subject to the Basic Regulation are State aircraft and those coming within one of the categories listed in Annex II to that Regulation. UK-registered aircraft which are subject to the Basic Regulation must comply instead with the environmental standards provided for in that Regulation and in Regulation 1702/2003/EC (the relevant implementing rules).[57]

Chapter 14 standards from 31 December 2017

The successor standard to Chapter 4 – called (somewhat confusingly) Chapter 14 will be 7dB below the Chapter 4 standard.[58] It is applicable to new aeroplane types submitted for certification on or after 31 December 2017 at or above 55 tonnes in weight, and on or after 31

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55 AEF/Green Skies, *Aircraft Noise* [accessed 13 February 2017]
56 by EU Directive 92/14/EEC
57 for further information see the EASA website [accessed 13 February 2017]
58 ICAO press notice, "ICAO Environmental Protection Committee Delivers Progress on New Aircraft CO2 and Noise Standards", 14 February 2013

December 2020 for aeroplanes less than 55 tonnes in weight.[59] EASA incorporated the change to Chapter 14 into EU law in 2016.[60]

Sustainable Aviation said that this would lead to a significant improvement in noise pollution over the following 35 years, but the AEF warned that older non-compliant aircraft may not be retired, so the benefits realised from the phase out of Chapter 2 aircraft (see above) may not be realised on the same scale in the future.[61]

[59] EASA, *Notice of Proposed Amendment 2014-15: Implementation of CAEP/9 amendments - Update of CS-34 and CS-36*, 24 June 2014, p6

[60] EASA press notice, "EASA welcomes ICAO agreement on new aircraft CO2 and noise standards", 22 February 2013 and *Regulation (EU) 2016/4 amending Regulation (EC) No 216/2008 … as regards essential requirements for environmental protection*, 5 January 2016

[61] Sustainable Aviation, The SA Noise Road Map, April 2013, p39; and op cit., Evidence to the Airports Commission: Comments on Discussion Paper 05: Aviation Noise, para 6.1.2

4. Compensation

The Government's view is that airport operators should offer households exposed to levels of noise of 69 dB LAeq,16h or more, assistance with the costs of moving and offer acoustic insulation to noise-sensitive buildings, such as schools and hospitals, exposed to levels of noise of 63 dB LAeq,16h or more. Where acoustic insulation cannot provide an appropriate or cost-effective solution, alternative mitigation measures should be offered. If no such schemes already exist, airport operators should consider financial assistance towards acoustic insulation for households.[62]

The Airports Commission recommended inn its July 2015 final report that the Government should introduce a noise charge or levy at major UK airports to ensure that airport users pay more to compensate local communities.[63] In its February 2017 consultation on airspace change the Government concluded that a noise levy applied to all major airports regardless of whether they are expanding would "not be proportionate", however, it did support measures at individual airports (see Heathrow, below).[64]

Further, in the airspace consultation the Government proposed that four proposed changes to current compensation policy:

1. Change the policy wording to remove the word 'development' in terms of when financial assistance towards insulation is expected so that compensation is applicable regardless of the type of change (infrastructure or airspace change);
2. Change the policy wording to allow for financial assistance towards insulation in the 63dB LAeq level or above to be applicable regardless of the level of change that causes a property to be in that noise contour level (i.e. remove requirement for a minimum 3dB change);
3. Inclusion of additional wording in the policy to encourage an airspace change promoter to consider compensation for significantly increased overflight as a result of the change based on appropriate metrics, which could be decided upon according to the local circumstances and economics of the change proposal; and
4. Include a requirement of an offer of full insulation to be paid for by the airport for homes within the 69dB LAeq or more contour, where the home owners do not want to move.[65]

In its July 2013 discussion paper the Airports Commission looked at compensation schemes in the UK and other parts of the world. It found that historically the compensation schemes in place at major UK airports had typically contributed half of the costs of new double-glazed

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[62] op cit., *Aviation Policy Framework*, paras 3.36-8
[63] op cit., *Final Report*, p31
[64] op cit., *UK Airspace Policy: A framework for balanced decisions: on the design and use of airspace*, pp36-7
[65] ibid., p37

windows. The Commission stated that UK schemes were often less generous than those in other countries, though this could be at least in part due to the fact that central or local government contributions in many other countries were greater (where their airports are often state-owned).[66] Responding to the paper the AEF said that existing approaches to the monetisation of noise impacts, through differential landing charges or the limited noise compensation schemes available at some airports, "fall a long way short of anything we would consider to be an effective, evidence-based approach to either noise abatement or compensation for noise damage" and recommended alternatives.[67]

4.1 Heathrow

In spring 2014 Heathrow announced a new compensation package for people who would be most disrupted by the future expansion of the airport, which involve payments of 25 per cent above market value for properties subject to compulsory purchase, stamp duty and legal fees; and a further £550 million fund for noise insulation and property compensation.[68]

In February 2015 it followed this with a new scheme to offer insulation to homes within the 55db Lden noise contour; residents would be eligible regardless of whether they experienced noise under existing flight paths or would be newly affected by noise from a new runway. Homes in the designated zone closest to the airport with higher levels of noise would have the full costs of their noise insulation covered by the airport. In addition, up to £3,000 in noise insulation would be offered to homes further away from the airport. The airport estimated the costs of the scheme somewhere in the region of £700 million.[69]

In February 2017 the Government published its draft National Policy Statement (NPS) for airports in the South East of England. This set out its support for the development of an ongoing Community Compensation Fund at an expanded Heathrow. This stated that "Heathrow Airport must fulfil its statutory obligations on compensation" and indicated its support for a noise levy at Heathrow of 50 pence per passenger, which could raise around £50 million per annum.[70]

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[66] op cit., *Discussion Paper 05: Aviation Noise*, para 5.42
[67] op cit., *Evidence to the Airports Commission: Comments on Discussion Paper 05: Aviation Noise*, p10
[68] HAHL press notice, "Heathrow proposes higher compensation for people most affected by a new runway", 10 May 2014
[69] HAHL press notice, "Heathrow responds to calls for world - class noise insulation scheme", 2 February 2015
[70] DfT, *Consultation on Draft Airports National Policy Statement: new runway capacity and infrastructure at airports in the south-east of England*, 2 February 2017, pp33-4

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How does living with aircraft noise affect wellbeing? A study of UK airports

Airports are associated with air and noise pollution and may, therefore, reduce the quality of life of local people. This study assessed the link between aircraft noise and subjective wellbeing, using data from 17 English airports. The authors conclude that living under flight paths has a negative effect on people's overall wellbeing, equivalent to around half of the effect of being a smoker for some indicators.

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Air traffic in Europe is expected to increase between 1.4 and 2.2 times by 2030[1], due to increasing demand for air travel and trade links with emerging international markets. To cope with this increase in demand, proposals for airport expansion have been made. In the UK, for example, three airport expansions have been suggested, and are currently being assessed in terms of economic, environmental[2] and human health impacts. Airport expansion is a contentious issue, with environmental groups and scientists citing the potential climate impacts and local residents fearing economic consequences, such as loss of property value.

This study focused on the impact of aircraft noise on subjective measures of wellbeing. Transportation noise has been linked to adverse effects on quality of life, wellbeing and health, due to factors such as stress, anxiety and raised blood pressure. Noise is a leading environmental complaint in the EU, regulated by the Environmental Noise Directive. Although there are well-established links between noise and physical health, evidence on the link to subjective measures of wellbeing, such as life satisfaction and happiness, is lacking.

The UK-based researchers assessed how living near to airports (or underneath flight paths) explained variation in people's responses to questions on subjective measures of wellbeing in a large national survey. They combined household data on subjective wellbeing (measured by questions on happiness, life satisfaction, sense of worthwhile/purpose in life, anxiety and positive 'affective balance' — based on happiness minus anxiety) with geographical data on airport proximity (within 5 km) and measures of aviation noise in decibels. This is the first time these datasets have been used to study household-level aviation impacts.

The major data source used for the study was the Annual Population Survey, an annual survey of around 155 000 households and 360 000 people in the UK. Using postcodes, data from the survey was matched to noise-measurement maps compiled by DEFRA and provided by the Cabinet Office. Noise data included day- and night-time noise, measured between June and September 2012. In total, the data includes a two-year sample of almost 190 000 households (over 20 times that of previous similar studies) with information on noise and proximity for 17 airports in England.

The researchers created models for: airport proximity; presence of daytime aircraft noise; and presence of night-time aircraft noise. Airport proximity was not significantly associated with any of the subjective wellbeing variables, suggesting that living close to an airport alone (i.e. without noise pollution) does not have a noticeable impact on subjective wellbeing.

Continued on next page.

1. EuroControl (2013) Challenges of Growth 2013 Summary Report. European Organisation for the Safety of Air Navigation, Brussels, Belgium.

2. For more information on the environmental impact of aviation in Europe, see the 2016 European Aviation Environmental Report: http://ec.europa.eu/transport/modes/air/aviation-strategy/documents/european-aviation-environmental-report-2016-72dpi.pdf

Science for Environment Policy

How does living with aircraft noise affect wellbeing? A study of UK airports *(continued)*

08 July 2016
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Source: Lawton, R. and Fujiwara, D. (2016). Living with aircraft noise: Airport proximity, aviation noise and subjective wellbeing in England. *Transportation Research Part D: Transport and Environment*, 42: 104–118. DOI: 10.1016/j.trd.2015.11.002

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Living within a daytime aircraft noise path (with noise at or above 55 decibels), however, was negatively associated with all measures of subjective wellbeing: lower life satisfaction, lower sense of worthwhile, lower happiness, lower positive affect balance, and increased anxiety. The authors found consistently negative and significant results across all five variables. The researchers could also predict the effect on subjective wellbeing associated with each decibel increase in noise, which they say has potential for modelling the possible wellbeing impacts due to changes in aircraft noise.

Although there were consistent negative impacts from daytime noise across all measures of wellbeing, the magnitude of these associations were small compared to other common drivers of wellbeing, such as unemployment, poor health and smoking (the negative effects of which are at least twice that of aviation noise).

The researchers found no evidence that night-time noise affects subjective wellbeing. There is a possibility, however, not explored in the study, that the noise had a physiological effect on the individuals. Furthermore, the sample of residences affected by night-time noise at or above 50 decibels was 50% lower than for daytime noise, which may affect the significance of the results.

This is the first study to merge national household-level data with geographic location data on airport proximity and objective measures of noise in England, enabling the authors to assess how aviation influences quality of life on a sample over 100 times bigger than the most prominent previous study. Based on their results, the researchers conclude that living under air-traffic flight paths may have a negative impact on subjective wellbeing. These findings support lower real-estate market demand in areas where there is aviation noise.

THANET DISTRICT COUNCIL

MANSTON AIRPORT NIGHT NOISE ASSESSMENT REVIEW

4222827/R01

November 2010

BUREAU VERITAS

Move Forward with Confidence

Document Control Sheet

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1.0 Summary

1.0.1 On behalf of Thanet District Council (TDC), Bureau Veritas (BV) have undertaken a review the Night Noise Assessment prepared by Bickerdike Allen Partners (BAP) for Kent International (Manston) Airport (MSE). The Night-time Flying Policy which is based on some of the findings of the Night Noise Assessment has also been reviewed.

1.0.2 The Night Noise Assessment has shown that significant numbers of people living in the vicinity of Manston Airport (MSE) are likely to experience noise impact due to forecast operations in 2018.

1.0.3 The Night Noise Assessment suggests that these impacts could be mitigated by means of a quota count system to limit aircraft movements during the core (6.5 hour) night period, and a sound insulation scheme which could be offered to residents whose dwellings are exposed to 57 dB $L_{Aeq,8h}$ or more.

1.0.4 Even with this in place, it is BV's view is that the predicted number of people likely to be exposed to significant levels of average night-time noise is not sufficiently justified by the number of passengers and freight activity that are forecast to benefit from the proposals. This is on the basis that the number of people likely to be impacted by night noise at MSE, normalised with respect to the annual passenger throughput, is greater than that at each of the designated London airports,

1.0.5 BV considers that there is a good case for seeking a lower annual quota limit than the 1995 proposed. Alternative lower limits have been proposed for consideration which would place MSE in line with the quota limits at other airports. At the designated London airports, the quota limit is accompanied by a movement limit and it would be good practice to include a movement limit in any quota count regime established at MSE. Introducing this measure and lowering the quota count limit would mean that the control system would take effect at a lower level of noise impact, thus limiting disturbance to a lower level.

1.0.6 In order to reduce noise impact on nearby residents due to individual aircraft movements, BV would recommend that bedrooms of dwellings predicted to be exposed to 90 dB(A) SEL or more are also included in the sound insulation scheme.

1.0.7 BV suggests an additional control to protect residents from noise impact during the whole night-time period, i.e. including the evening and morning shoulder-periods when the majority of night-flights are to occur. Imposing a suitable area limit for the 48 dB $L_{Aeq,8h}$ night noise contour would be an appropriate means for controlling this.

1.0.8 It is BV's recommendation that the above points are considered for inclusion in the Night-time Flying Policy.

1.0.9 The conclusions on noise impact have been based upon computer noise modelling undertaken by BAP. BV has reviewed the input assumptions for this modelling and, using these, has undertaken their own independent noise modelling. The results of this have shown the contour modelling undertaken by BAP is accurate and representative of the input data provided.

2.0 Introduction

2.0.1 Bureau Veritas (BV) has been tasked by Thanet District Council (TDC) to review the Night Noise Assessment prepared by Bickerdike Allen Partners (BAP) on behalf of Kent International (Manston) Airport (MSE), and the resulting Night-time Flying Policy.

2.0.2 MSE is proposing to implement a night flying policy which is based on the night noise assessment. There is an obligation on TDC to have that assessment independently reviewed and verified. The scope of the brief involves both reviewing the noise assessment, but also commenting on the merits of the proposed policy that has been based on that assessment.

2.0.3 BV has reviewed the following relevant documents relating to noise:

- The proposed Night-time Flying Policy;
- The Night Noise Assessment report; and
- The INM Input Assumptions report.

3.0 Night Noise

3.0.1 Night noise has been recognised as being one of the major noise problems relating to airports for many years. This was particularly reflected in December 2003, in the Department for Transport (DfT) publication entitled the Future of Air Transport, known as the Air Transport White Paper (ATWP)[1]. In that it sets out a measured and balanced approach to providing a strategic framework for the development of air travel in the UK over the next 30 years.

3.0.2 Paragraph 3.13 of the ATWP[2] states:

'The Government recognises that noise from aircraft operations at night is widely regarded as the least acceptable aspect of aircraft operations. We will bear down on night noise accordingly, but we must strike a fair balance between local disturbance, the limits of social acceptability and the economic benefits of night flights. This should be done on a case-by-case basis.'

3.0.3 At the main London airports, various night noise control regimes have existed for many years. Currently, these are based on the relative noise levels generated by different aircraft together with the number of movements. The current method is based on the Quota Count (QC) system, which assigns a QC value to individual aircraft depending on the noise they generate on departure and arrival. There are limits on the total quota and number of movements that can use the particular airport at night.

3.0.4 At the London airports, and elsewhere, noise infringement limits also exist for departures during the night-time. The noise limits are often lower than equivalent daytime limits, reflecting the greater sensitivity of noise at night, and the fines levied on the airlines for exceeding the limits are often higher than for daytime infringements.

3.0.5 Some airports also have night-time $L_{Aeq,8h}$ noise contour area limits.

3.0.6 In connection with airports, night-time has attracted several definitions:

- 8 hour (23:00 – 07:00h): as referred to in Planning Policy Guidance Note 24 (PPG24)[3] and the Environmental Noise Directive (END)[4];
- 6.5 hour (23:30 – 06:00h): as used for the quota system at the London airports;
- 7 hour (23:00 – 06:00h): used by some airports for their noise infringement policy; and
- 23:00 – 23:30h and 06:00 – 07:00h: which are known as evening and morning shoulder periods respectively.

3.0.7 The Night Noise Guidelines for Europe were produced by the World Health Organisation (WHO) in 2009[5]. This document aimed to present the conclusions of the WHO working group responsible for preparing guidelines for exposure to noise during sleep. The need for these 'health-based' guidelines originated in part from the END which compels European Union Member States to produce noise maps and data about night exposure from mid-2007.

3.0.8 These guidelines use the 8 hour night-time period. There is therefore an increasing case for controlling noise during this period.

[1] The Future of Air Transport White Paper – Department for Transport (DfT). December 2003

[2] It is recognized that the ATWP was published under the previous Government. At the time of writing there is no indication that the current Coalition government views night noise any differently

[3] Planning Policy Guidance Note 24 (PPG24)

[4] EU Directive 2002-49-EC Environmental Noise Directive (END)

[5] World Health Organisation – Night Noise Guidelines for Europe. 2009

4.0 Review: Aircraft Night Noise Assessment Report

4.0.1 The Night Noise Assessment produced by BAP provides an introduction, description of the airport site and surrounding areas, their assessment criteria, their noise contouring and assessment methodologies, and their impact assessment. Eleven accompanying figures have also been provided, as well as the noise modelling assumptions in an appendix. The appendix is reviewed in section 5 below of this BV report.

4.0.2 The reviews of these sections of the BAP report are presented below. Key issues are described and reference is made to the figures where necessary.

4.1 Description of the airport

4.1.1 MSE is located in the Isle of Thanet, about 3 km to the west of Ramsgate town (just over 1 km from the nearest residential area), about 4 km south of Westgate and about 5 km to the southwest of Margate. Lying between about 1 and 3 km from the airport are a number of small villages such as Woodchurch, Manston and Acol to the north, and Minster and Cliffs End to the south. The village of St Nicholas Wade is located about 6 km to the west of the airport.

4.1.2 The airport operates with a preference for departures to the west on runway 28 and arrivals from the west on runway 10 (when weather conditions permit such operations to occur in a safe manner) to minimise noise impact on the more densely populated areas to the east of the airport.

4.1.3 The noise abatement departure route requiring operators of jet and large aircraft to make a right turn to the northwest at a distance of around 1.5 miles from the centre of the airport runway, as long as operationally safe to do so, will minimise departure noise impact to residents of Herne Bay.

4.2 Need for additional night operations

4.2.1 The Introduction states that MSE is seeking to agree a policy with Thanet District Council to establish a regular schedule of flights into and out of the airport that will occur between the recognised night-time hours of 23:00 and 07:00h.

4.2.2 Given the sensitivity of night flights, and the comments in the ATWP, whilst MSE clearly desires night flights, there is an obligation to be sure that the economic benefits from those flights do justify the inevitable disturbance that will occur. This aspect is considered later in section 4.6.

4.3 Aircraft Movements and the Quota Count system

4.3.1 The Night Noise Policy is to be based on the Quota Count system, which prohibits certain noisy aircraft types from flying between 23:00 and 07:00h, and sets quota limits for operations between 23:30 and 06:00h. Versions of this system have been used at UK airports including Heathrow, Stansted, Gatwick, Manchester and Bristol. The details of the Quota Count system are given in the Noise Restriction Notice published by NATS[6].

4.3.2 Choosing to use this 'tried and tested' system for MSE is therefore appropriate, on the condition that a suitable quota limit is agreed. Having said that, this system only controls activity between 23.30 and 06.00 hours, which on its own would leave the shoulder periods uncontrolled (other than by the inherent runway capacity).

[6] London Heathrow, London Gatwick and London Stansted Airports Noise Restrictions Notice 2009, ref S 8/2009, 26th February 2009.

4.3.3 Tables 5 and 6 of the Airport Master Plan provide information on the total annual and average daily forecast aircraft movements, including passenger, freight and other (namely general aviation). This is repeated below:

Figure 1: Forecast Annual and Daily Average Aircraft Movements in 2018

Category	2010	2013	2018	2033
Passenger	352	1,003	20,325	31,509
Freight	473	977	2,619	6,251
Other	17,259	20,001	23,195	36,137
TOTAL	**18,084**	**21,488**	**46,139**	**73,897**

Category	2010	2013	2018	2033
Passenger	1	3	56	97
Freight	2	3	8	18
Other	48	55	64	72
TOTAL	**51**	**61**	**128**	**187**

4.3.4 Section 3.2 of the BAP report presents the projected night-time movements for 2018. These have been reviewed by BV and are repeated below:

Table 1: Night-time Aircraft Movements in 2018

	Annual		**Typical night**	
Hours	**Passenger**	**Freight**	**Passenger**	**Freight**
23.00-23.30	1016	157	2.8	0.4
23.30-06.00	610	471	1.7	1.3
06.00-07.00	407	157	1.1	0.4
Total	**2033**	**785**	**5.6**	**2.1**

4.3.5 Comparing these, we can see that the night-time (8 hour) operations would account for 6.1% of the total forecast movements in 2018. Compared with airports elsewhere this is about the average proportion. Night-time passenger and freight movements would account for 10% and 30% of the total movements within these respective categories.

4.3.6 Considering the 6.5 hour night quota count period, night operations would account for 2.3% of the total forecast movements (3% for passenger and 18% for freight categories separately). As would be expected, in terms of the total airport activity, there is a weighting towards freight movements at night.

4.3.7 The fleet mix of aircraft types proposed to operate during the 6.5 hour night quota count period is presented in Table 1 of the BAP INM Assumptions report. These have been repeated below along with the quota counts associated with the aircraft, and a calculation of what the annual quota count would be on the basis of the forecast. Note that as some aircraft types have a range of QCs depending on variant and take-off weight, calculations have been undertaken on the basis of all aircraft on their minimum, maximum and likely modal QC:

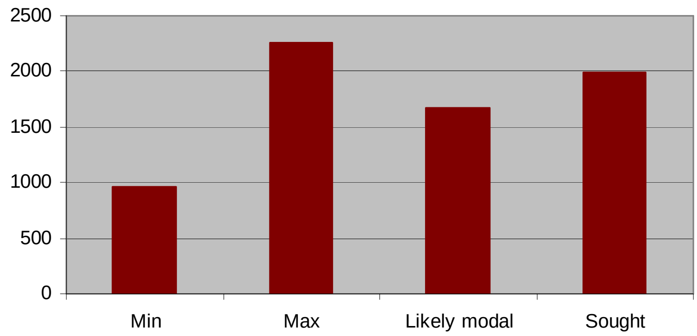
Table 2: Night-time Quota Count Analysis

A/C type	Annual mvts in QC period	Minimum QC				Maximum QC				Likely modal QC			
		Arrival		Departure		Arrival		Departure		Arrival		Departure	
		A/C QC	Quota	A/C QC	Quota	A/C QC	Quota	A/C QC	Quota	A/C QC	Quota	A/C QC	Quota
A320	183	0.25	23	1	46	1	46	1	92	1	46	1	69
A340	30	0.5	8	1	15	1	15	4	60	1	8	2	30
738	183	0.5	46	1	46	1	46	1	92	1	46	1	69
752	61	0.25	8	1	15	1	31	1	31	1	15	1	31
DH8D	91	0.5	23	0	0	1	23	0	0	1	23	0	0
E195*	61	0.25	8	1	15	1	15	1	31	1	15	1	23
A300	24	1	12	2	24	2	24	2	24	1	6	2	24
A310	24	0.5	6	1	12	1	12	2	24	1	12	2	24
A330	24	0.5	6	1	12	1	6	2	24	1	6	2	24
744	141	1	71	2	141	2	141	4	282	2	141	4	282
748**	47	0.5	12	1	24	1	24	2	47	1	24	2	47
DC10	71	2	71	2	71	4	142	8	284	4	142	4	142
DC8	47	0.8	19	2	47	8	188	16	376	2	47	8	188
MD11	94	2	94	2	94	2	94	2	94	2	94	2	94
Sum	1081		404		562		806		1459		624		1046
Total Quota		966				2265				1669			

* QC not listed, therefore set as for A320
** QC not listed, therefore set as half the QC for 747-400 (in accordance with BAP movement assumption)

4.3.8 The QC system proposed for MSE seeks a quota count for the calendar year of 1995 for the Night-time Quota Count Period. Comparing this with the above analysis shows that the quota sought is towards the high end of the possible range (from 966 to 2265). This is illustrated in Figure 2 below:

Figure 2: Quota comparison



4.3.9 Table 1 above also supports the assertion made in section 3.2 of the BAP report that over 60% of night operations will take place during the shoulder periods, which as indicated above is not controlled by the quota system. BAP also mention that it is generally accepted that the most sensitive time for people at night is the quota count period, and particularly during the hours of 01:00 and 06:00. People are, however, also sensitive to noise when they are trying to get to sleep and soon before waking up in the morning, i.e. during the shoulder periods. Noise impact during the shoulder periods could be regulated by imposing a limit on the area of an $L_{Aeq,8h}$ night-time noise contour, as suggested in section 4.6.19 below.

4.3.10 An indication of the severity of night noise controls is given by considering the average quota count per aircraft movement within the night quota period. The policy proposes an annual quota of 1995 created by 1081 movements, giving a quota count per aircraft movement of

1.85. The current regime at London Heathrow permits an annual quota of 9180 created by 6320 movements, giving a quota count per aircraft movement of 1.45. The corresponding figures for Gatwick and Stansted are 0.62 and 0.67 respectively.

4.3.11 It can be seen that for the anticipated number of night movements, the average quota count per aircraft movement at MSE is greater than at any of the three designated London airports. If the average quota count for Heathrow was applied, the annual quota limit would be just under 1570. If the equivalent for Stansted was applied, the annual quota limit would be about 725. It can be seen that 1570 (relating to Heathrow) fits within the range of likely total quota depending on the exact aircraft types used, but 725 (relating to Stansted) would be unlikely to permit the proposed number and mix of aircraft movements. This is due to the bias towards larger aircraft types proposed for MSE compared with the mix at Stansted. Therefore, there is a good case for seeking a lower annual quota limit to reduce the potential noise impact at night.

4.3.12 At the designated airports, the quota limit is accompanied by a movement limit. It would be good practice to include a movement limit in any quota count regime established at MSE.

4.3.13 The final paragraph of this section in the BAP report states that the L_{Aeq} night noise contours have been generated on the basis of the full 8-hour night. This is appropriate referring to the assessment criteria (below). Furthermore, as 60% of night movements occur during the (total) 1.5 hour shoulder period, the 8-hour contours present a far better representation of the night noise impact.

4.4 Night Noise Assessment Criteria

Criteria for average noise levels

4.4.1 Sleep disturbance relating to average night-time noise levels evaluated using the $L_{Aeq,8h}$ noise contours is considered. On the basis of a detailed review of a number of sources, the night-time criterion of 55 dB $L_{Aeq,8h}$ has been selected. This is 7 dB higher than the 48 dB $L_{Aeq,8h}$ which is based on the PPG24 boundaries.

4.4.2 Noise abatement objectives at Heathrow, Gatwick and Stansted restrict the Night Quota Period (6.5 hour) 48 dB(A) contour areas, and other airports including Manchester and London Luton regularly produce 48 dB $L_{Aeq,8h}$ night noise contours to give an indication of their control of night noise disturbance. A precedent for using 48 dB(A) has therefore been set.

4.4.3 The BAP report provides some evidence to justify the view that higher noise levels are acceptable. I.e. at some UK airports, dwellings have been exposed to noise levels in excess of 60 dB $L_{Aeq,16h}$. It is assumed there is a typo here, and that $L_{Aeq,8h}$ was intended. This includes Nottingham East Midlands Airport (NEMA) where over 200 dwellings were exposed to ≥ 60 dB $L_{Aeq,8h}$ in 2004. Another example for comparison would be Stansted. In 2006, fewer than 100 dwellings were exposed to ≥ 60 dB $L_{Aeq,8h}$ based on an annual average day[7]. As the assessment for MSE has also been based on an annual average day, this is a fair comparison,

4.4.4 A key source which has not been included in the review is the World Health Organisation's (WHO) Night Noise Guidelines for Europe[8]. The WHO Regional Office for Europe developed the Night noise guidelines for Europe to provide expertise and scientific advice to the European Member States in developing future legislations in the area of night noise exposure control and surveillance, with the support of the European Commission. This guidelines document reviews the health effects of night time noise exposure, examines exposure-effects relations, and presents guideline values of night noise exposure to prevent harmful effects of

[7] ERCD Report 0708, London Stansted Airport, Strategic Noise Maps 2006
[8] World Health Organisation – Night Noise Guidelines for Europe. 2009

night noise in Europe. Although these guidelines are neither standards nor legally binding criteria, they are designed to offer guidance in reducing the health impacts of night noise based on expert evaluation of scientific evidence in Europe.

4.4.5 Guidelines are given in terms of the $L_{night,outside}$ noise metric (L_{night} is the same as $L_{Aeq,8h}$ but is an annual average night rather than the more usual summer average night).

4.4.6 Quoting from the document, based on the systematic review of evidence produced by epidemiological and experimental studies, the relationship between night noise exposure and health effects can be summarised as below in Figure 3.

Figure 3: Effects of Different Levels of Night Noise on the Population's Health

Average night noise level over a year $L_{night,outside}$	Health effects observed in the population
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

4.4.7 Below the level of 30 dB $L_{night,outside}$, no effects on sleep are observed except for a slight increase in the frequency of body movements during sleep due to night noise. There is no sufficient evidence that the biological effects observed at the level below 40 dB $L_{night,outside}$ are harmful to health. However, adverse health effects are observed at the level above 40 dB $L_{night,outside}$, such as self-reported sleep disturbance, environmental insomnia, and increased use of somnifacient drugs and sedatives.

4.4.8 Therefore, 40 dB $L_{night,outside}$ is equivalent to the lowest observed adverse effect level (LOAEL) for night noise. Above 55 dB the cardiovascular effects become the major public health concern, which are likely to be less dependent on the nature of the noise. Closer examination of the precise impact will be necessary in the range between 30 dB and 55 dB as much will depend on the detailed circumstances of each case.

4.4.9 Based on the exposure-effects relationship summarised in Figure 3, the following night noise guideline values for the protection of public health from night noise are recommended by the WHO:

- Night noise guideline (NNG) $L_{night,outside}$ = 40 dB
- Interim target (IT) $L_{night,outside}$ = 55 dB

4.4.10 These values are supported as follows: For the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than 40 dB of $L_{night,outside}$ during the part of the night when most people are in bed. The LOAEL of night noise, 40 dB $L_{night,outside}$, can be considered a health-based limit value of the night noise guidelines (NNG) necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise.

4.4.11 An interim target (IT) of 55 dB $L_{night,outside}$ is recommended in the situations where the achievement of NNG is not feasible in the short run for various reasons. It should be emphasized that IT is not a health-based limit value by itself. Vulnerable groups cannot be protected at this level. Therefore, IT should be considered only as a feasibility-based intermediate target which can be temporarily considered by policy-makers for exceptional local situations.

4.4.12 Given this analysis, using the 55 dB(A), $L_{Aeq,8h}$ value is too high, and as used at other airports, there is a compelling case to use the 48 dB $L_{Aeq,8h}$ as the night noise target, which lies between the NNG and IT levels and offers a good compromise between the two.

Criteria for noise from individual aircraft events

4.4.13 BAP has based their criteria for assessing noise from individual aircraft events again on a number of sources of information, including guidance in PPG24 as appropriate. They cite the Department of Transport research study[9] on the effect of night noise which formed the basis of 90 dB(A) SEL being considered the threshold of significance for individual night-time aircraft events. They have, however, interpreted the observation that 90 dB(A) SEL causes an average person a 1/75 chance of being 'wakened' as:

- being outside 90 dB(A) SEL poses no significant risk;
- being exposed to 90 dB(A) SEL at night has 'a very slight risk of sleep disturbance'.

4.4.14 Consequently, Table 3 of the BAP report indicates no significant risk if there are no more than 13 events producing noise at a level of 90 dB(A) SEL, and a slight risk if there are no more than six events producing noise at a level of 95 dB(A) SEL.

4.4.15 It was subsequently established (at the Heathrow Terminal 5 Inquiry) that this research result did not take account of the effect of:

- having difficulty in going to sleep;
- having difficulty in getting back to sleep; and
- early awakening

4.4.16 Another source is the work undertaken by Griefahn and Scheuck[10]. An analysis is presented by BAP which takes account of the sound reduction that may be expected from outside to inside through a closed single glazed window, which amounts to 27 dB(A) as established in PPG24. In this section, there are believed to be a number of typos. Firstly, the number of

[9] Report of a Field Study of Aircraft Noise and Sleep Disturbance. Department of Transport, Dec 1992, Ollerhead J B et al (1992).
[10] Scheuch K, Griefahn B, Jansen G, Spreng M (2003). Evaluation criteria for aircraft noise. Rev Environ Health, Jul-Sep 2003, 18(3), 185-201.

events at certain noise levels should refer to outdoor conditions (rather than indoor). Secondly, the Threshold Value item should read ‘23 events @ 67 dB L_{Amax} outdoors (approximately 75 dB(A) SEL)’. This is considerably lower than the 77 dB L_{Amax} outdoors and 85 dB(A) SEL quoted.

4.4.17 Two key sources of information relating to individual events have not been mentioned. British Standard BS8233[11] draws on the results of research and experience to provide information on the design of buildings that have internal acoustic environments appropriate to their functions. It deals with control of noise from outside the building, amongst other things. It advises that the indoor L_{Amax} at night should not to exceed 45 dB(A). Again considering an attenuation of 27 dB(A) through a closed window, this would mean an outdoor L_{Amax} limit of 72 dB (broadly equivalent to an SEL of 80 dB(A)).

4.4.18 The second source is again the WHO Night Noise Guidelines for Europe. It notes that short-term health effects are mainly related to maximum levels per event inside a bedroom, i.e. $L_{Amax,inside}$. A number of instantaneous effects are connected to threshold levels expressed in L_{Amax} (see Figure 4 below) however the health relevance cannot be easily established. The report states, however, that ‘it can be safely assumed that an increase in the number of such events over the baseline may constitute a subclinical adverse health effect by itself leading to significant clinical health outcomes.’

Figure 4: Summary of effects and threshold levels for effects where sufficient evidence is available

Effect		Indicator	Threshold, dB	Reference (chapter, section)
Biological effects	Change in cardiovascular activity	*	*	3.1.5
	EEG awakening	$L_{Amax, inside}$	35	4.10
	Motility, onset of motility	$L_{Amax, inside}$	32	3.1.8, dose–effect relation for aircraft
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	$L_{Amax, inside}$	35	3.1
	Waking up in the night and/ or too early in the morning	$L_{Amax, inside}$	42	3.1.7, dose–effect relation for aircraft

4.4.19 As the figure shows, indoor L_{Amax} threshold values are actually lower than the guidance given in BS8233.

4.4.20 Table 3 of the BAP report summarises the night noise criteria. BV would suggest that standard practice is adopted, i.e. that the 48 dB $L_{Aeq,8h}$ is used to assess the number of dwellings/people affected by average noise over the 8-hour night-time period, and that >55 dB $L_{Aeq,8h}$ would lead to a risk of more than just ‘some’ sleep disturbance.

4.4.21 Bearing in mind that the L_{Amax} assessment is based on closed windows, BV would also suggest that 80 dB(A) SEL is considered the threshold of acceptability for individual aircraft events at night in line with current standard practice.

[11] BS8233:1999 Sound insulation and noise reduction for buildings - Code of practice

4.5 Noise Contour and Assessment Methodology

4.5.1 The methodology used for producing the noise contours and the assessment methodology is presented in detail in the BAP INM Assessment report. This is reviewed in detail in section 5 below.

4.6 Impact of Night-time Airborne Aircraft Noise

8-hour L_{Aeq} night-time noise contours

4.6.1 The impact assessment begins by reviewing current night operations. It is stated that no dwellings are located within the 48 dB $L_{Aeq,8h}$ night noise contour due to airport activity in 2009. This suggests no significant impact relating to average noise levels during the night-time period (i.e. without considering individual noise events).

4.6.2 This contour is reported to occupy an area of less than 1.0 km^2. The text states that the contours for 2009 are presented in Figure 2.1, but this has not been made available. It would be useful to see this contour to enable a visual comparison to be made between the current and future noise impacts.

4.6.3 The predicted night-time $L_{Aeq,8h}$ noise contours relating to future night operations in 2018 are presented in BAP Figure 2. Table 4 in the BAP report shows the numbers of dwellings enclosed by these contours 48 to 72 dB(A) in steps of 3 dB. These show that 6386 dwellings may be exposed to 48 dB $L_{Aeq,8h}$ or more, which is a significant number. Additionally, 318 dwellings would be eligible for sound insulation treatment following BAP's recommendation to treat properties exposed to 57 dB $L_{Aeq,8h}$. If all habitable rooms are treated under the scheme, it would also offer a benefit to residents during the daytime.

4.6.4 The CACI database also includes population data from which the number of people exposed to the various noise levels has been provided in the BAP INM Assessment report. These show that 13443 people are likely to be exposed to noise levels of 48 dB $L_{Aeq,8h}$ or more in 2018.

4.6.5 The report states that around 800 dwellings will lie inside the 55 dB(A) contour which is proposed by BAP in their Table 3 to be the threshold of 'risk of some sleep disturbance'. Section 6.2 of the BAP report does suggest that it will give rise 'to a slight risk of sleep disturbance' which is not quite consistent with the nomenclature given in their Table 3. It would also be appropriate for the calculated population and dwelling data relating to this contour band to be presented in the INM Assumptions report.

4.6.6 For comparative purposes the numbers of dwellings exposed to a level of 55 dB $L_{Aeq,8h}$ around NEMA, Stansted, Gatwick and Heathrow Airports have been presented. BV notes that the data used in these examples are drawn from 2003 and 2004 and is rather old. More up-to-date information is available in the draft Airport Noise Action Plans, submitted to Defra to ultimately meet the requirements of the END.

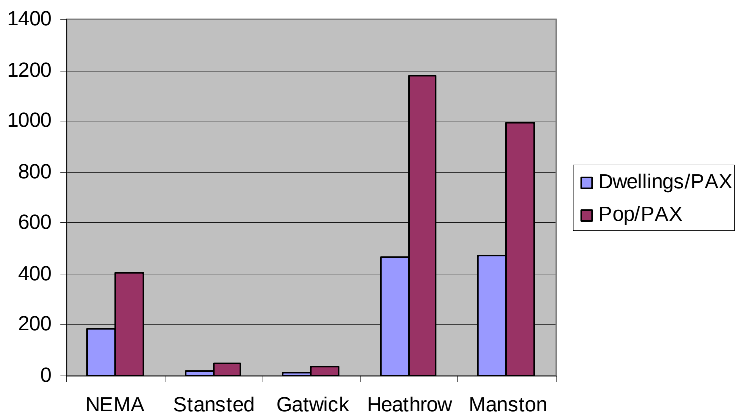
4.6.7 Data on the number of dwellings and population exposed to noise are presented below for 2006 for the above airports, and compared with MSE in 2018. Note that this data is not publicly available for the 55 dB $L_{Aeq,8h}$, so the closest value has been chosen, i.e. 54 dB $L_{Aeq,8h}$.

4.6.8 We have also normalised these against the annual passenger throughput so that comparisons of disbenefit (i.e. number of dwellings exposed) can be made between the airports on more equal terms (a more equitable analysis would be to normalise the dwelling and population data with night-time passenger/freight throughput, but this data is not available). The results of this have also been presented graphically in Figure 5.

Table 3: 54 dB $L_{Aeq,8h}$ Night-time Noise Exposure Analysis

Airport	Year	Exposed		Passengers	Dwellings/ PAX	Pop/ PAX
		Dwellings	Population	(mppa)		
Nottingham East Midlands Airport	2006	950	2100	5.20	183	404
Stansted	2006	450	1200	23.68	19	51
Gatwick	2006	450	1100	32.00	14	34
Heathrow	2006	31250	79500	67.34	464	1181
Manston	2018	1088	2272	2.29	475	992

Figure 5: Night-time Noise Exposure Analysis – dwellings and population within the 54 dB $L_{Aeq,8h}$ contour, per million passengers



4.6.9 This analysis shows significant variation between airports. Heathrow clearly causes the greatest normalised disbenefit owing to the fact that it is located close to the highly populated areas of west London, despite the fact that it caters for twice the number of passengers of the next busiest airport, Gatwick, which affects comparatively few people hence the low normalised disbenefit. Stansted is a similar example to Gatwick. The normalised disbenefit for regional airports such as NEMA is somewhere in the middle as the low passenger throughput pushes up the normalised disbenefit despite the comparatively few people exposed to noise. On the basis of the forecasts, however, MSE is showing a greater normalised disbenefit to that of Heathrow in terms of dwellings exposed to 54 dB $L_{Aeq,8h}$. In fact, the predicted number of people exposed to this level of noise at MSE is over double the number that were exposed to noise at Stansted and at Gatwick airports which cater for 10-15 times the number of passengers.

4.6.10 This is a slightly unfair analysis as it is relating night noise impact against total passenger throughput. It would be helpful to have an idea of the likely night time passenger throughput (and freight movement) during the night for MSE and other airports so the relative impact of the night activity can be estimated.

<u>SEL footprints</u>

4.6.11 Like L_{eq} contours, SEL footprints are lines of constant noise level on the ground. However, they represent noise levels for one single aircraft movement, rather than the aggregation of noise from an average day's (or night's) traffic. SEL footprints are expressed in terms of sound exposure level (SEL)[12], rather than L_{eq}.

4.6.12 85, 90 and 95 dB(A) SEL footprints are presented in BAP Figures 3.1 to 5.2. These have been calculated for the Boeing 737-800, 747-400 and the MD11 and relate mainly to westerly operations on runway 28 (easterly SEL footprints are presented only for the Boeing 747-400). The justification for this is that a greater number of dwellings/people are exposed to 95 dB(A) SEL during westerly departures and arrivals than easterly operations. BAP have asserted that 95 dB(A) SEL indicates a slight risk of sleep disturbance provided there are fewer than (or equal to) six events per night.

4.6.13 BV considers that 80 dB(A) SEL is a more appropriate threshold of significance. On this basis, Table 7 of the BAP INM Assessment report indicates that departures to the east on runway 10 will affect the greatest number of people, i.e. those living in the densely populated areas of Ramsgate. 80 dB(A) SEL contours have not been calculated but the populations predicted to be within the 85 dB(A) contour by such departures ranges from 14722 for MD11 departures, up to 30903 for the Boeing 747-400. This is a significant number of people.

4.6.14 The report recommends that given the small number of night-time aircraft events, it would be inappropriate to control aircraft noise by way of the SEL unit. BV would suggest that having no control over individual aircraft noise events at night could potentially leave a small number of dwellings exposed to in excess of 95 dB(A) SEL unprotected. Additionally, a large number of properties in the west of Ramsgate are also enclosed by the 90 dB(A) SEL contour but lie outside the proposed 57 dB $L_{Aeq,8h}$ sound insulation eligibility contour, and may suffer significant disturbance.

4.6.15 London Heathrow Airport sets a benchmark which BV would suggest is adopted for MSE. It operates a domestic noise insulation scheme to address the impacts of night flights on local communities. It is designed to protect residents who are regularly exposed to noise from night flights.

4.6.16 It is based on the 90 dB(A) SEL noise footprint of the noisiest aircraft that operates in the night quota period (23:30 - 06:00h). Rooms eligible for insulation are bedrooms or bed-sitting rooms only (which are used as bedrooms on most days of the year). The scheme provides noise insulation for all bedrooms or bed-sitting areas in approx 41,000 homes around Heathrow.

4.6.17 Those local residents who benefit from the sound insulation may still be disturbed, however, if they wish to open windows during the summer months. Opening windows renders any sound insulation treatment (to glazing) ineffective.

4.6.18 The report states that with a suitable sound insulation scheme in place, together with a suitable night noise quota count limit, the proposed night-time activities in 2018 at MSE are not expected to have any significant noise impact on the local community. BV considers that the proposed quota count limit of 1995 is too high to offer adequate protection. An annual limit based on an average quota count per movement that is closer to those at other airports may be more appropriate.

4.6.19 The quota count scheme puts a limit on noise impact during the 6.5-hour core night for local residents, but this leaves the evening and morning shoulder periods un-restricted. Owing to the fact that two-thirds of night operations are proposed during these periods, BV considers it appropriate to impose a limit on the area of the 48 dB $L_{Aeq,8h}$ night-time noise contour.

4.6.20 Such a limit should be chosen carefully to strike a suitable balance between the needs of the airport to expand, and the rights of local residents not to be unduly impacted by noise from

[12] Sound Exposure Level (sometimes called the Single Event Level) is a measure of the total sound energy associated with a single noise event (such as an aircraft over-flight). The SEL value represents the total amount of acoustic energy that occurred during the actual noise event under consideration, but as if it had all occurred in a one second period..

the aircraft. This limit should be agreed by the local authority and included in the Night-time Flying Policy.

4.6.21 Even with this in place, it is BV's view is that the predicted number of people likely to be exposed to significant levels of average night-time noise is not sufficiently justified by the number of passengers that are forecast to benefit from the proposals.

5.0 Review: Night Noise Contours INM Assumptions Report

5.0.1 This report sets out the assumptions used in the computation of the night-time airborne aircraft noise contours upon which the Night Noise Assessment reviewed in section 4 was based.

5.1 The Airport

5.1.1 The information given in section 2.0 of the report is accurate taking information from the relevant pages of the UK Air Pilot (EGMH AD 2.12 – Manston).

5.2 Aircraft operations

5.2.1 Annual aircraft movement data has been supplied to BAP from the Airport. This data has been provided in Table 1 of the INM Assumptions report. BV has reviewed how BAP has compiled this data, using their previous experience and clarifications from the airport, into a form suitable for analysis.

5.3 Flight tracks

5.3.1 Section 3.3 of the BAP report refers to SIDs and STARs. These are Standard Instrument Departure (routes) and Standard Instrument Arrival (routes). Indeed, no such routes are available in the UK Aeronautical Information Package (AIP) which is the usual source of this information. There is not a formal requirement for an airport to have designated SIDs and STARs, but it is considered good practice, particularly for larger airports.

5.3.2 Appropriately, departure and arrival routes for the noise model have instead been generated based on information provided by the Airport and confirmed through consultation with Air Traffic Control.

5.3.3 Details of the routes include that arrivals follow the extended centre line of the runways for compatibility with the Airport's Instrumented Landing System (ILS), and the right turn on westerly departures to avoid the built-up areas of Herne Bay. Training circuits have also been included in the model.

5.3.4 The BAP report states that a preliminary analysis showed that the SEL contours do not extend as far as the points on the departure routes provided by the Airport where aircraft become directed by Air Traffic Control (ATC). The 85 dB(A) SEL figures for the Boeing 747-400 (Figures 4.1-4.4 in the BAP Noise Assessment report) do appear to extend slightly beyond 4 DME for departures on runway 10, but as this is over the Thames Estuary, we confirm this aspect of the modelling is appropriate.

5.3.5 One slight concern relates to Figure 1 of the BAP Noise Assessment report which shows the tracks to lie around 100 m to the north of the runway position; they should lie on the runway. This may be a graphical alignment issue in the preparation of the figure, but if a similar misalignment with respect to the contour figures and CACI population database prevails, the population assessment in section 6 of the BAP Noise Assessment report may not be accurate.

5.3.6 Confirmation should therefore be sought over whether the misalignment of the tracks in Figure 1 has affected the analysis.

5.4 Dispersion

5.4.1 To account for the dispersion of the actual tracks flown by departing aircraft about the departure route, BAP have used their standard dispersion model which has been determined from data collected at other similar airports. BV considers this model to be appropriate.

5.5 Flight profiles

5.5.1 The flight profiles modelled by BAP are dependent upon the take-off weight of an aircraft. This is dependent upon fuel load and the number of passengers (or freight load). As the number of passengers or freight load may vary significantly from flight to flight, the standard approach is to base departure profiles on fuel load. This is in turn dependent on the distance to destination, and it is on this basis that the 'stage length' has been assigned to the various aircraft types. BV considers this approach to be appropriate.

5.5.2 A 3.0° approach angle is used for all aircraft. This is standard practice for arriving aircraft at the majority of airports worldwide.

5.6 Traffic distribution by route

5.6.1 BAP has used the runway utilisation observed at MSE in 2009 to set the runway split for the model for 2018. This assumes 33% easterly operations on runway 10, and 67% westerly operations on runway 28.

5.6.2 Although a reasonable split given the prevailing wind direction in the UK, this does not appear to consider the preference for routing operations to the west of the airport (i.e. a preference for arrivals on runway 10 as well as departures on runway 28). This preference is described in qualitative terms in the proposed Night-time Flying Policy document, and could reduce noise impact on local residents. Adopting a runway split of 67% westerly is therefore considered appropriate for the purpose of noise modelling.

5.7 INM model

5.7.1 Noise contour predictions were made using version 7.0b of the Federal Aviation Administration (FAA) Integrated Noise Model (INM) prediction software. This is the most recent version of one of two software packages that are widely accepted and used in the acoustics profession for predicting airborne aircraft noise. The other is the ANCON model which is used by, amongst others, the Civil Aviation Authority for generating contours for BAA airports. There are accepted differences between the two packages, but both are generally considered to be sufficiently accurate.

5.8 INM model – assumptions

5.8.1 The ground topography used is assumed to be flat. This is an acceptable assumption given the limited topography in the vicinity of the airport. It may, in fact, be a conservative assumption as the Noise Assessment Report states that the western edge of Ramsgate Town lies at a lower ground level than the runway and ground levels continue to fall towards the sea. Noise levels in these areas may therefore be lower than predicted. BAP have estimated that this would reduce the noise levels incident on properties beneath the flight path in this zone by around 0.5 to 1 dB as compared to predicted noise levels.

5.8.2 The default headwind of 14.8 km/h and all-soft ground lateral attenuation assumptions are appropriate.

5.8.3 Through many previous similar studies, BAP have undertaken validation exercises and refined the model input assumptions for certain aircraft types to better reflect actual aircraft operation and resulting noise levels. The modified aircraft types are either:

- smaller than the types the software was initially designed for, and known not to be so accurate (in the case of the Dash 8-Q400);
- relatively new, and the model data is limited or unavailable in INM 7.0b (as is the case for the Embraer 195); or

- not currently in operation (as is the case for the Boeing 747-800).

5.8.4 The approach taken by BAP is to adjust the movement numbers and aircraft type, which BV considers to be entirely reasonable and justifiable.

5.8.5 Table 5 in the BAP report lists the modelling input data. This level of disclosure is welcomed as it facilitates verification of the modelling and analysis of the resulting noise contours.

5.9 Contour areas and population counts

5.9.1 The 2009 and 2018 night noise contours have been produced on the basis of annual aircraft movement data. Contours are often produced for movements relating to the 92-day summer period (from 16th June to 15th September inclusive) which is considered to reflect the busiest months and therefore present a worst-case in terms of noise emission. Producing contours based on annual data is, nevertheless, a valid approach so long as this is born in mind when carrying out the assessment.

5.9.2 The population and dwelling counts have been determined using 2009 Census data by postcode location provided by CACI Ltd. This is a standard source of data, and the 2009 Census is understood to have been the most up-to-date version at the time of writing.

5.9.3 This CACI database does have some limitations. Listing data by postcode can mean that large population/dwelling numbers spread over an area can be attributed to a single geographical location. Some postcode locations may fall near to a contour line, so the resulting counts could be significantly affected by only a small change in the position of the contour line.

5.9.4 The CACI database is, however, widely used and understood to provide reasonable indications of population and dwelling counts enclosed by noise contours, amongst other things.

5.10 Summary

5.10.1 The aircraft noise modelling undertaken by BAP has been reviewed by BV and found to be acceptable. Clarification should, however, be sought on whether the misalignment of the tracks in Figure 1 has affected the presentation of the contour plots and the analysis of dwelling and population count data.

6.0 Review: INM Model

6.0.1 BV has produced night noise contours using the same modelling software as that used by BAP. The model has been built from scratch using the assumptions presented by BAP in their document titled 'Manston Airport Night Noise Contours INM Assumptions' (ref. A9293-R01-AH 28/09/10).

6.0.2 The review of the noise predictions will be on the basis of how closely the contour lines produced by BAP's modelling, and the resulting enclosed areas, are to those modelled by BV.

6.1 Input data

6.1.1 The validity of the input assumptions has been reviewed in section 5 above, all assumptions have been found to be appropriate. The input data used is taken from the BAP INM Assumptions report and is summarised below:

6.1.2 General aspects relating to the INM study

- Software/version: Integrated Noise Model (INM) 7.0b (09/28/2009)
- Headwind: 14.8 km/h
- Temperature: 15℃
- Pressure: 759.97 mm-Hg
- Noise Metric: $L_{Aeq,8h}$, A-weighted, exposure, where 10 Log(T) = 44.59

6.1.3 Airport

- Runway labels: 10/28
- Runway Bearing: 101.24°(True)
- Runway dimensions: Length = 2752 m, Width = 61 m.
- No displaced runway thresholds

6.1.4 Flight tracks

- Entered as described in BAP INM Assumptions report section 3.3, i.e.:
- Arrivals straight in on both runways
- Departures on runway 10: straight ahead
- Departures on runway 28: straight ahead to 1.5 DME where they turn at a radius of 2 km onto a bearing of 310°(magnetic). At Manston, magnetic declination is 1°11' west, hence true bearing of 309°.
- No circuits were applicable to night operation, so these were not modelled.

6.1.5 Runway utilisation (split)

- 33% easterly (runway 10), 67% westerly (runway 28)

6.1.6 Dispersion

- 53.3% of movements on main track, 22.2% on inner sub-track, 1.15% on outer sub-track.
- Outer sub-track displacement perpendicular to main track is at 2.71 x standard deviation as calculated by BAP from previous studies. Outer sub-track displacements use as follows:

Table 4: Route dispersion

Distance along track from SOR (km)	Outer sub-track displacement (m)	Outer sub-track displacement (nm)
2.752 (end of runway)	0	0.0000
3.5	105	0.0567
4.0	211	0.1139
4.5	323	0.1744
5.0	434	0.2343
5.5	556	0.3002
6.0	678	0.3661
6.5	792	0.4276
7.0	905	0.4887
7.5	1007	0.5437
8.0	1109	0.5988
8.5	1184	0.6393
9.0	1260	0.6803
9.5	1324	0.7149
10.0	1387	0.7489
10.5	1444	0.7797
11.0 and above	1500	0.8099

6.1.7 Aircraft movements – the following aircraft movements were calculated by BV from the annual movement data for 2018 as provided by the airport (Table 1 of BAP INM Assumptions report). These were used in the model to generate the 2018 noise contours.

Table 5: Aircraft movement data

INM Aircraft type	Runway/ operation	Stage length	Daily movements	Equivalent Annual movements
744	10DEP	1	0.1241	45
	10ARR	1	0.1241	45
	28DEP	1	0.2519	92
	28ARR	1	0.2519	92
737800	10DEP	2	0.2758	101
	10ARR	2	0.2758	101
	28DEP	2	0.5599	204
	28ARR	2	0.5599	204
757RR	10DEP	5	0.0922	34
	10ARR	5	0.0922	34
	28DEP	5	0.1872	68
	28ARR	5	0.1872	68

A300B4-203	10DEP	1	0.0181	7
	10ARR	1	0.0181	7
	28DEP	1	0.0367	13
	28ARR	1	0.0367	13
A310-304	10DEP	1	0.0181	7
	10ARR	1	0.0181	7
	28DEP	1	0.0367	13
	28ARR	1	0.0367	13
A319-131	10DEP	2	0.1844	67
	10ARR	2	0.1844	67
	28DEP	2	0.3745	137
	28ARR	2	0.3745	137
A320-211	10DEP	2	0.2758	101
	10ARR	2	0.2758	101
	28DEP	2	0.5599	204
	28ARR	2	0.5599	204
A330	10DEP	1	0.0181	7
	10ARR	1	0.0181	7
	28DEP	1	0.0367	13
	28ARR	1	0.0367	13
A340-211	10DEP	6	0.0457	17
	10ARR	6	0.0457	17
	28DEP	6	0.0927	34
	28ARR	6	0.0927	34
DC1010	10DEP	1	0.0538	20
	10ARR	1	0.0538	20
	28DEP	1	0.1092	40
	28ARR	1	0.1092	40
DC860	10DEP	1	0.0357	13
	10ARR	1	0.0357	13
	28DEP	1	0.0725	26
	28ARR	1	0.0725	26
DHC6	10DEP	1	0.1374	50
	10ARR	1	0	0
	28DEP	1	0.2790	102
	28ARR	1	0	0
MD11GE	10DEP	1	0.0705	26
	10ARR	1	0.0705	26
	28DEP	1	0.1432	52
	28ARR	1	0.1432	52
SD330	10DEP	1	0	0
	10ARR	1	0.1787	65
	28DEP	1	0	0
	28ARR	1	0.3627	132

6.1.8 Note that there are a few minor differences between this input data and that presented in Table 5 of the INM Assumptions report. However, these differences generally appear to be due to rounding and all are sufficiently small to have no significant effect on the resulting noise contours.

6.1.9 Model run options

- Lateral attenuation: All-soft-ground
- Contour grid: Recursive, refinement = 9, tolerance = 0.10

6.2 Output: 8-hour night-time noise contour

6.2.1 The contours have been calculated at levels from 47 to 73 dB in steps of 1 dB. Without having access to the digital mapping used by BAP to present their contours (Figure 2 of their Aircraft Night Noise Assessment Report), BV has not been able to prepare a formal comparative figure.

6.2.2 The BV contours have, however, been superimposed manually onto the BAP figure for comparative purposes. This shows that the contours modelled by BAP are very close to the contours modelled by BV. Owing to the inherent accuracy of the modelling, it is customary to consider that the contours are accurate if they are within ±1 dB of the reference set. This is the case with the BAP contours.

6.2.3 In addition, the contour areas have been calculated and presented, again in 1 dB steps, in Table 6 below. Here, the results are compared with the contour areas calculated by BAP.

Table 6: 8-hour night-time contour area comparison

Contour level	Contour area, (km^2)	
	BV	BAP
47	17.3	
48	14.5	14.4
49	12.1	
50	10.2	
51	8.5	8.5
52	7.1	
53	5.9	
54	4.9	4.9
55	4.1	
56	3.4	
57	2.8	2.8
58	2.3	
59	2.0	
60	1.7	1.6
61	1.4	
62	1.2	
63	1.0	1.0
64	0.9	
65	0.8	
66	0.7	0.7
67	0.6	
68	0.5	
69	0.4	0.4
70	0.4	
71	0.3	
72	0.3	0.3
73	0.2	

6.2.4 It can be seen that the areas enclosed by each of the contours calculated by BAP are within the areas calculated for the adjacent contour values. For example, the area predicted by BAP for the 48 dB $L_{Aeq,8h}$ contour is less than that for the 47 dB contour, and greater than that for the 49 dB contour. In many cases, the predicted areas are the same. This further shows that the BAP contours are accurate.

6.3 Output: SEL noise footprints

6.3.1 In addition to the 8-hour night-noise contours, SEL noise footprint contours have also been calculated by BV and compared with the predictions made by BAP in the same way as for the 8-hour night-time L_{Aeq} contours. A comparison of the contour areas is presented below for the scenarios illustrated in BAP figures 3.1 to 5.2.

Table 7: SEL footprint noise contour areas (km^2)

Contour level, dB(A)	738-28A		738-28D		MD11-28A		MD11-28D	
	BV	BAP	BV	BAP	BV	BAP	BV	BAP
84	6.2		13.9		7.5		13.2	
85	4.9	4.9	11.6	11.6	6.2	6.2	11.2	11.2
86	3.9		9.8		5.0		9.5	
89	1.9		6.4		2.6		6.1	
90	1.5	1.5	5.4	5.4	1.8	1.8	5.4	5.4
91	1.2		4.5		1.4		4.8	
94	0.6		2.5		0.8		3.1	
95	0.5	0.5	2.0	2.0	0.6	0.6	2.5	2.5
96	0.4		1.6		0.5		2.0	

Contour level, dB(A)	744-28A		744-28D		744-10A		744-10D	
	BV	BAP	BV	BAP	BV	BAP	BV	BAP
84	17.6		25.0		17.6		25.0	
85	14.6	14.6	20.5	20.5	14.6	14.6	20.5	20.5
86	11.9		16.9		11.9		16.9	
89	6.5		9.7		6.5		9.7	
90	5.3	5.3	8.1	8.1	5.3	5.3	8.0	8.0
91	4.3		6.7		4.3		6.7	
94	2.3		3.8		2.3		3.8	
95	1.9	1.9	3.1	3.1	1.9	1.9	3.1	3.1
96	1.6		2.6		1.6		2.6	

6.3.2 For the scenarios calculated, the areas enclosed by the 85, 90 and 95 dB(A), as predicted by BAP, match the BV predictions exactly (to 1 decimal place).

6.4 Summary of noise modelling

6.4.1 On the basis of the above analysis, BV concludes that the contour modelling undertaken by BAP is accurate and representative of the input data provided.

7.0 Review: Manston Airport – Proposed Night-time Flying Policy

7.0.1 The Proposed Night-time Flying Policy document begins with sections on Background, the Airport's Master Plan, and Market and Business Requirements which aim to justify the case for increasing night-time operations and therefore the need to draw up the policy.

7.1 The Policy

7.1.1 The actual policy is set out in paragraphs 18- 23. Comments on these follow:

7.1.2 Paragraphs 18-20: Brief description of Quota Count (QC) systems in general.

7.1.3 Paragraph 21: Includes details of the proposed QC system for Manston:

- Items a-c help define the QC system, but these are standard definitions.
- Item d prevents aircraft with QC great than QC4 from being scheduled during the night-time period (23:00 – 07:00h). This is appropriate as it restricts all aircraft which are noisier than the largest forecast aircraft type, the Boeing 747-400.
- Item e defines the annual quota limit of 1995. As mentioned in section 4 of this report, BV considers this to be too high, and that a limit closer to 1570 would be more appropriate.
- Item f asks that the preferred departure runway and noise abatement routes are used whenever possible during the night-time period consistent with safe operations. This would minimise the number of operations over the more densely populated areas in Ramsgate, and continue to route aircraft departing from runway 28 on the right-hand turn to avoid over-flying Herne Bay. It is therefore welcomed.
- Item g recognises that aircraft operating to the west of the airport will impact fewer people and will therefore count towards the annual quota and community contribution at 50% of their certified rate. BV feels that it is right that an incentive is given to operating in this manner, however with the quota limit already considered too high, this feature may stop the system biting in the protection of nearby residents, particularly those in Ramsgate. A lower quota limit is therefore recommended.
- Item h follows from item d and offers a community contribution of £1,000 for each occasion a movement exceeding QC4 occurs at MSE during the night-time quota period. Note that no contribution will be paid for movements occurring during the shoulder periods, i.e. between the hours of 23:00 and 23:30, and 06:00 to 07:00. Furthermore, following item g, the contribution will be £500 for movements operating to the west of the airport. It is recommended that to offer a suitable incentive, the community contribution should apply to movements during the full night-time period.
- Item i includes that MSE will guarantee minimum annual contributions to MAEIF (assumed Manston Airport Environmental Improvement Fund) of £10,000.

7.1.4 Paragraph 22: Sets out the requirement for monthly quota monitoring reports which are to be submitted to Thanet District Council (TDC) and the Airport Consultative Committee. This is an appropriate arrangement.

7.1.5 Paragraph 23: Sets out that the airport will publish monthly noise data on its website to make it available to members of the public. Such transparency promotes good community relations, but it should be clarified what noise data will be published, and in what format. This should be agreed with TDC prior to acceptance of the policy.

7.2 Impact Assessment

7.2.1 The final paragraphs of the document are concerned with the impact assessment:

7.2.2 Paragraph 24: Describes the noise impact assessment prepared by Bickerdike Allen Partners, which BV has reviewed in section 4 of this report.

7.2.3 Paragraph 25: Draws attention to the consideration made in the noise impact assessment for the development of a sound insulation scheme, where properties contained within the 57 dB $L_{Aeq,8h}$ night noise contour are to be eligible for sound insulation treatment to be fitted at the airport's expense. It is on the basis of the actual annual noise contour rather than a forecast contour, so properties only become eligible after having already been exposed to such noise levels for up to 12 months. It would be recommended that the eligibility be based on forecast contours to enable residents to be protected prior to being exposed to the qualifying level of noise.

7.2.4 Paragraph 26: States that the MSE is committed to developing and agreeing such a scheme with TDC prior to any dwellings being encompassed by this contour. The wording does not categorically state that the airport will develop and agree such a scheme with TDC; it is suggested that the wording is changed to clearly state this. It is also suggested that such a scheme is developed and agreed at the time of agreeing the Night-time Flying Policy so that local residents are adequately protected from the adverse effects of night-time aircraft noise.

7.3 Suggested items also to be included in the policy

7.3.1 As stated in section 4.6 of this report, BV also suggests that the sound insulation scheme includes properties contained within the 90 dB(A) SEL noise contour of the noisiest aircraft forecast to regularly depart during the night-time period. This should be included in the Night-time Flying Policy.

7.3.2 Also as stated in section 4.6 of this report, BV suggests that a limit is imposed on the area contained by the 48 dB $L_{Aeq,8h}$ night-time noise contour to limit the potential noise impact on local residents due to night-time operations including those during the shoulder periods.

8.0 Conclusions

8.0.1 Significant numbers of people living in the vicinity of Manston Airport (MSE) are likely to experience noise impact due to forecast operations in 2018.

8.0.2 The Night Noise Assessment suggests that these impacts could be mitigated by means of a quota count system to limit aircraft movements during the core (6.5 hour) night period, and a sound insulation scheme which is proposed to be offered to residents whose dwellings are exposed to 57 dB $L_{Aeq,8h}$ or more. It is hoped that this scheme would apply to habitable rooms including living rooms so that benefit is also afforded during the daytime.

8.0.3 Even with this in place, it is BV's view is that the predicted number of people likely to be exposed to significant levels of average night-time noise is not sufficiently justified by the number of passengers and freight activity that are forecast to benefit from the proposals.

8.0.4 BV considers that there is a good case for seeking a lower annual quota limit. A limit of just under 1570 would keep it within the range of likely total quota depending on the exact aircraft types used, and place it in line with the quota limit at London Heathrow. At the designated London airports, the quota limit is accompanied by a movement limit and it would be good practice to include a movement limit in any quota count regime established at MSE.

8.0.5 In order to reduce the likely noise impact on nearby residents, BV would recommend that bedrooms of dwellings exposed to 90 dB(A) SEL or more are also included in the proposed sound insulation scheme.

8.0.6 BV suggests an additional control to protect residents from noise impact during the whole night-time period, i.e. including the evening and morning shoulder-periods when the majority of night-flights are to occur. Imposing a suitable area limit for the 48 dB $L_{Aeq,8h}$ night noise contour would be an appropriate means for controlling this.

8.0.7 It is BV's recommendation that the above points are considered for inclusion in the Night-time Flying Policy.

8.0.8 The conclusions on noise impact have been based upon computer noise modelling undertaken by BAP. BV has reviewed the input assumptions for this modelling and, using these, has undertaken their own independent noise modelling. The results of this have shown the contour modelling undertaken by BAP is accurate and representative of the input data provided.