Gatwick Airport Northern Runway Project

Environmental Statement
Appendix 18.4.1: Methods Statement for Health and Wellbeing

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1 Introduction

1.1.1 This document forms **ES Appendix 18.4.1: Methods Statement for Health and Wellbeing** (Doc Ref. 5.3) of the Environmental Statement (ES) prepared on behalf of Gatwick Airport Limited (GAL) for the proposal to make best use of Gatwick Airport's existing runways and infrastructure (referred to within this report as 'the Project').

1.1.2 This appendix describes in further detail the methods used to inform the assessment set out in by **ES Chapter 18: Health and Wellbeing** (Doc Ref. 5.1). The appendix discusses qualitative methods, quantitative methods and assumptions and limitations.

2 Qualitative methods

2.1 Vulnerable group sub-populations and assessment of inequalities

2.1.1 Communities where polluting human activities are sited often show disadvantage in terms of social and economic variables. The majority of associations support an increased burden on vulnerable categories, especially ethnic minorities and unemployed. However, several relationships are found in the opposite direction or in both ways, particularly with wealth and education, reflecting a mixed reality where potential discrimination in siting decisions coexists with socioeconomic benefits for nearby communities due to industrial development (Davide, Alessandra, & Roberto, 2022).

2.1.2 Within a defined population, individuals will range in level of sensitivity due to a series of factors such as age, socio-economic deprivation, and the prevalence of any pre-existing health conditions which could become exacerbated. Sensitive individuals can be considered particularly vulnerable to changes in environmental and socio-economic factors (both adversely and beneficially), whereby they could experience disproportionate effects when compared to the general population.

2.1.3 As an example, the elderly, young children and individuals with chronic pre-existing respiratory conditions would be more sensitive to adverse changes to air quality, with the potential for emergency admission to hospital more likely than for someone of working age who has good respiratory health. On the other hand, an individual who has been unemployed for a long period of time would benefit more from employment opportunities generated by the Project in comparison to an individual who is already employed.

2.1.4 An extensive amount of baseline data has been collected in order to interpret local health circumstances. This information is set out in **Appendix 18.5.1: Health Baseline Trends, Priorities and Vulnerable Groups** and **Appendix 18.5.2: Health and Wellbeing Baseline Data Tables** (Doc Ref. 5.3) and summarised within Section 18.5 of **ES Chapter 18: Health and Wellbeing** (Doc Ref. 5.1). Overall, it is concluded that local health circumstances are good. As an example of this conclusion, 2019 health deprivation data (provided by the Index of Multiple Deprivation) show that within the local study area, the mean, median and modal deprivation deciles for all Lower layer Super Output Areas (LSOAs) are 8, 9 and 10 – where 10 represents areas within the least deprived 10% of all LSOAs in England and 1 represents the most deprived 10% of all LSOAs in England.

2.1.5 As such, when looking at the population in general, the existing burden of poor health is low. However, it is recognised that there will be individuals within a defined population who are particularly sensitive and could experience disproportionate effects. On this basis, a precautionary approach has been applied by assuming that the vulnerable sub-population for each determinant of health is of high sensitivity. For example, there are pockets of poorer health outcomes as measured by data for under 75-year-old mortality from causes considered preventable (OHID, 2021)).

2.1.6 In line with the guidance listed in Section 18.4 of **ES Chapter 18: Health and Wellbeing** (Doc Ref. 5.1), a population health approach has been taken, informed by discussion of receptors within the other technical chapters of the ES.

2.1.7 For each determinant of health, **ES Chapter 18: Health and Wellbeing** (Doc Ref. 5.1) identifies relevant inequalities through consideration of the differential effect to the 'general population' of the relevant study area and effects to the 'vulnerable population group' of that study area. The vulnerable population group being comprised of relevant sensitivities for that determinant of health. The differentiation of the general population from the vulnerable group population, allows a discussion of any potentially significant health inequalities and the targeting of any mitigation. The following population groups have been considered:

- The 'general population' including residents, passengers, visitors, workers, service providers, and service users.
- The 'vulnerable group population' comprised of the vulnerabilities due to young age, older age, income, health status, social disadvantage and access or geographic reasons (see paragraph 2.1.10 below).

2.1.8 That there is variation between people is widely acknowledged in public health. Public health frames this variation in terms of a likely distribution of effects within a population. This distribution can be applied conceptually or statistically but tends to show that most individuals are likely to experience an average level of change. This links to the 'general population' analysis.

2.1.9 Because there are invariably people towards the extremes of the distribution, eg experiencing much smaller or larger effects, it is relevant to also consider sub-populations who may be more likely to experience such extremes because of certain characteristics. This links to the 'vulnerable group' analysis.

2.1.10 The methods draw on the list of vulnerable population groups set out in guidance. The following six broad population groups are used to inform a consistent narrative on potential health inequalities across the assessment. These groups are broadly defined to facilitate a consistent discussion across health issues. People falling into more than one group may be especially sensitive:

- Young age: Children and young people (including pregnant women and unborn children).
- Old age: Older people (particularly frail elderly).
- Low income: People on low income, who are economically inactive or unemployed/workless.
- Poor health: People with existing poor health; those with existing long-term physical or mental health conditions or disability that substantially affects their ability to carry out normal day-to-day activities.
- Social disadvantage: People who suffer discrimination or other social disadvantage, including relevant protected characteristics under the Equality Act 2010 or groups who may experience low social status or social isolation for other reasons.
- Access and geographical factors: People experiencing barriers in access to services, amenities and facilities and people living in areas known to exhibit high deprivation or poor economic and/or health indicators.

2.1.11 As, all development has the potential for adverse effects to some particularly vulnerable individuals, the role of EIA health significance conclusions is not to set a threshold of 'no harm' from development, but to show where, at a population level, the harm should weigh strongly in the balance alongside the development's benefits for health and other outcomes.

2.1.12 Furthermore, as stated by IEMA 2022 guidance (Pyper, et al., 2022a):

'Where the effect is best characterised as only affecting a few individuals, this may indicate that a population health effect would not occur. Such individuals should still be the subject of mitigation and discussion, but in EIA and public health terms the effect may not be a significant population health change' (page 23).

2.1.13 When comparing the DM and With Project scenarios the modelling in other ES chapters that informs the health assessment has appropriately taken into account population and dwelling counts within their zones of influence for relevant assessment years.

2.1.14 The health methods triangulate relevant evidence sources, including scientific literature, health policy, local health priorities, baseline data, regulatory standards and consultation responses. In this regard health in EIA is like other aspects of public health, where the scientific literature and WHO position statements are important but must be applied within the local context. The health assessment therefore has regard to WHO advisory guidelines but acknowledges that they are not always the most appropriate reference point in UK planning decisions. Where there are national health protection standards these are given weight, to do otherwise would undermine public confidence in them and the institutions that set them. In adopting this context-based approach, the health assessment follows guidance and good practice that is itself advocated by the WHO (WHO, 2018a; WHO, 2022).

2.1.15 In relation to regulatory thresholds or statutory standards the IEMA 2022 guidance states (Pyper, et al., 2022a):

'Regulatory thresholds, or statutory standards … cover the formal standards adopted by national jurisdictions. This may include statutory air quality standards, as well as standards set by, or commonly adopted in relation to, government noise policy. … Where thresholds have been set these do not mean that there would be no health effect below these levels. … In such cases an informed discussion about what is acceptable for the jurisdiction is appropriate. For example, giving the public confidence in thresholds and standards set by government for the purpose of health protection having taken into account other social, economic and environmental considerations' (page 24).

2.1.16 The methods take into account that a change in a determinant of health does not equate directly to a change in population health outcomes. Rather the change in a determinant alters risk factors for certain health outcomes. The assessment considers the degree and distribution of change in these pathways. The analysis of health pathways focuses on the risk factors and health outcomes that are most relevant to the determinants of health affected by the Project. As there are both complex and wide-ranging links between determinants of health, risk factors and health outcomes, it would not be proportionate or informative for an assessment to consider every interaction.

3 Quantitative methods

3.1 General

3.1.1 Two quantitative health analyses, related to air quality and noise, inform the determination of health significance. The quantitative analyses are pragmatic estimates of changes in selected health outcomes to identify the scale of change associated with the Project changes. The methods have been presented to the Health Topic Working Group and agreed as a reasonable basis of assessment.

3.1.2 There are no quantitative methods that are applicable to EIA that can determine the overall population health effects of a project across all determinants of health and health outcomes. For this reason, the primary analysis must be qualitative, as set out in Section 18.4 of **ES Chapter 18: Health and Wellbeing** (Doc Ref. 5.1), but the quantitative elements support verification of the professional judgment on the scale of change. The quantitative analysis is therefore an input to the qualitative health analysis. The qualitative analysis takes into account outcomes that are not covered by the quantitative analysis. The quantitative analysis is purposefully indicative, not exhaustive.

3.1.3 The underlying formula that is used by both quantitative analyses is as follows (PHE, 2014; WHO, 2018b):

3.1.4 The attributable burden of disease (or other health outcome) due to an environmental risk factor = Attributable Fraction x Population Size x Disease Rate

3.1.5 which can also be expressed as:

$$AB = \mathrm{AF} \times P \times B$$

$$AB = \frac{RR - 1}{RR} \times P \times B$$

3.1.6 Where:

- AB is the attributable burden of a specific health outcome in a given population that is identified as due to a specific exposure.
- AF is the attributable fraction, which is the proportion of the incidence rate of a given outcome in a given population that is identified as due to a given exposure.
- P is the population size (eg total number of dwellings within air quality model x average occupancy).
- B is the baseline annual rate of health outcome per person (eg ONS data for local authority for all 30+ natural causes of death, or all age hospital admission for respiratory or cardiovascular disease)
- RR is the relative risk of a change in a given health outcome due to a given change in exposure. These have two components: concentration response functions (CRF) which are derived from the scientific literature, eg Committee on the Medical Effects of Air Pollutants (COMEAP); and the actual change in exposure due to the Project (data provided from the air quality and noise models set out in **ES Chapter 13: Air Quality** (Doc Ref. 5.1); and **ES Chapter 14: Noise and Vibration** (Doc Ref. 5.1) respectively).

3.1.7 These are pragmatic formulae simplified from more complex epidemiological formulae by PHE to provide an estimate of changes in a health outcome for local authority level changes in exposure. Undertaking a more detailed or complex analysis would not be proportionate for an EIA, even this level of analysis is unusually high for an EIA health chapter.

3.1.8 It is noted that applying the results of the analyses presented here to smaller spatial areas than those reported or using the reported results as the inputs to further analyses, would not be consistent with the underpinning PHE methods that strike a careful balance between simplicity of approach and margin of error.

3.1.9 The health outcomes used by the quantitative health analysis reflect where the scientific literature identifies sufficiently robust CRFs that can be used by quantitative methods. Even here there are limitations in the understanding of causation and confounding factors, for example the most recent WHO (WHO, 2018a) noise CRFs for hypertension provide a central relative risk of 1.0 or less, which is equivalent to no change in health outcomes, or a protective effect on health outcomes in the case of being less than 1.0. Several of the noise CRFs are also based on evidence the WHO rates as low or very low quality.

3.1.10 The results of the analysis are best viewed as representing the increased risk to the local population, as a whole, associated with the change in exposure due to the Project. The results do not indicate how the mortality burdens are distributed across the local populations. The interpretation of changes in mortality is that the additional exposure has increased mortality risk in the local population to an amount equivalent to this number of deaths. The 'number of deaths' is a metric widely used in communicating about public health risks. It does not represent the number of individuals whose length of life has been shortened (PHE, 2014).

3.1.11 There is potential for double-counting effects due to co-exposure to noise and air pollution, so caution should be applied if summing the air pollution and noise health effects predicted in the assessment. This is a point taken into account in the interactions and cumulative assessments.

3.2 Air quality

3.2.1 **ES Chapter 13: Air Quality** (Doc Ref. 5.1) has predicted changes in concentrations of nitrogen dioxide (NO_2) and particulate matter in two size fractions, PM_{10} and $PM_{2.5}$, at sensitive receptor locations in the study area around the airport.

3.2.2 The quantitative health analysis formula (PHE, 2014) for air quality is as follows:

$$AB = \frac{RR_A - 1}{RR_A} \times P \times B$$

3.2.3 Where the relative risk of a change in a given air pollutant concentration (RR_A) is given by the formula:

$$RR_A = CRF^{(A/10)}$$

3.2.4 Where:

- AB is the attributable burden of a specific health outcome in a given population that is identified as due to a specific exposure.
- P is the population size exposed.
- B is the baseline annual rate of health outcome per person
- RR_A is the relative risk of a change in a given air pollutant concentration.
- CRF is the concentration response function for a given health outcome, which is derived from the scientific literature. The CRF is per 10 µg.m-3.
- A is the air pollutant concentration change in µg.m-3 (from the ES Air Quality assessment model), which allows the calculation of the relative risk for a given change in concentration other than 10 µg.m-3.

3.2.5 The CRFs used are listed in Table 3.2.1Table 3.2.1. These are recent evidence based CRFs from the national body Committee on the Medical Effects of Air Pollutants (COMEAP) that advises the Government on air quality. These COMEAP derived CRFs (COMEAP, 2020) were discussed and agreed with the Health Topic Working Group.

3.2.6 The option of using older WHO HRAPIE CRFs (WHO, 2013) was suggested by the assessment team to produce more conservative results, the HRAPIE CRFs generally being larger. The Health Topic Working Group recommended that the COMEAP coefficients should be used as they are more up-to-date and more relevant to the UK context. The COMEAP CRFs have therefore been applied.

3.2.7 The Health Topic Working Group also requested that a range be provided, not just the central estimate of each CRF. The assessment therefore takes the low and high confidence intervals reported by COMEAP and includes these within the analysis, see full results in **Appendix 18.8.1 Quantitative Health Assessment Results** (Doc Ref. 5.3). These ranges are provided for information, with the health assessment being informed by the results based on the central estimates of each CRF. This approach is consistent with the purpose of central estimates.

3.2.8 COMEAP note that the CRFs for $PM_{2.5}$ and NO_2 are likely to include an element of double counting if both are applied. COMEAP recommend two approaches:

- either use 25-55% (mid-point of range 40%) of the unadjusted NO_2 CRF, ie discounting the NO_2 CRF central estimate by a minimum of 45%, to calculate the NO_2 health outcome contribution, then adding the full $PM_{2.5}$ health outcome contribution to give the combined effect that avoids double counting;
- or going with just the higher result when calculating $PM_{2.5}$ and NO_2 outcomes, ie making no adjustments to the CRF but using only the larger of the full NO_2 or full $PM_{2.5}$ health outcome results to give the combined effect that avoids double counting.

3.2.9 As discussed with the Health Topic Working Group both approaches to avoiding double counting are reported in **Appendix 18.8.1 Quantitative Health Assessment Results** (Doc Ref. 5.3) and the more conservative of these approaches has been applied in **ES Chapter 18: Health and Wellbeing** (Doc Ref. 5.1) Section 18.8, ie the one that produces the larger change in health outcomes.

3.2.10 To be conservative the analysis has used the smallest discount within the range recommended by COMEAP, ie 55% of the unadjusted CRF (45% discount), rather than 40% of the unadjusted CRF (60% discount) or 25% of the unadjusted CRF (75% discount).

3.2.11 The results show the second of the two approaches recommended by COMEAP tends to produce the greater health outcomes, ie going with just the higher result when calculating $PM_{2.5}$ and NO_2 outcomes without CRF adjustment. The higher result tending to be the unadjusted NO_2 effect on health outcomes.

3.2.12 The COMEAP CRFs are for both short- and long-term changes in air pollutant concentrations. The **ES Chapter 13: Air Quality** (Doc Ref. 5.1) modelling data provides annual average concentrations, and short-term mortality impacts are therefore not assessed separately to avoid double-counting with long-term effects. The CRFs for long-term effects, being based mainly on cohort studies, are likely to capture short-term effects. Hospital admission CRFs are for daily-mean rather than annual-mean concentrations. However, for the purposes of this analysis they are treated as applicable to the annual mean, with the outcome likely to over-estimate any effect; daily mean effects typically being higher than annual mean effects.

3.2.13 The baseline annual rates of health outcomes are listed in Table 3.2.3Table 3.2.3. Baseline health rates are used and results are presented as changes in annual rates of disease or mortality (deaths brought forward) were the air pollution exposure to be at the predicted levels over the long term. This allows small cumulative long term changes in statistical life expectancy or disease risk to be expressed in a single year scenario for comparison of impacts with and without the Project.

Table 3.2.1: Air Pollutant Exposure-Response Metrics used at ES 2023

CRF	Pollutant	Health outcome	Averaging period	Low CRF	Central CRF *	High CRF	Age	Source	Reference within source
COMEAP long-term mortality	NO_2	30+ natural cause mortality	Annual	1.008	1.023	1.037	30+	COMEAP 2018	Nitrogen dioxide: effects on mortality - GOV.UK (www.gov.uk)
	$PM_{2.5}$		Annual	1.06	1.08	1.09	30+	COMEAP 2022a	Quantifying mortality associated with long-term exposure to PM2.5 (publishing.service.gov.uk)
COMEAP hospital admissions	NO_2	Respiratory disease hospital admissions, all ages	24-hr mean**	1.0033	1.0057	1.0082	All	COMEAP 2022b***	Hospital admissions associated with exposures to air pollutants (publishing.service.gov.uk)
	$PM_{2.5}$	Cardiovascular disease hospital admissions, all ages	24-hr mean**	1.0026	1.0090	1.0153	All		
	$PM_{2.5}$	Respiratory disease hospital admissions, all ages	24-hr mean**	0.9937	1.0096	1.0258	All		

* all per 10 µg.m^{-3} exposure. No upper or lower concentration thresholds have been applied as cut-offs (ie CRF = 1 at zero concentration is implicitly assumed).

** To be treated as equivalent to the annual mean in the analysis. Short-term effects are not assessed separately to avoid double counting.

*** Converted from % to CRF by dividing by 100 and adding 1.

Table 3.2.2: Other air quality exposure-response metrics the ES 2023 assessment had regard to

CRF combinations	Pollutant	Health outcome	Averaging period	Low CRF	Central CRF	High CRF	Age	Source	Reference within source
HRAPIE long-term mortality	NO2	30+ natural cause mortality	Annual mean	1.031	1.055	1.080	30+	HRAPIE 2013	HRAPIE recommends 33% discount to avoid double counting PM2.5.
	PM2.5	30+ natural cause mortality	Annual mean	1.04	1.062	1.083	30+	HRAPIE 2013	Health risks of air pollution in Europe – HRAPIE project, Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide (who.int)
HRAPIE hospital admissions	NO2	Respiratory disease hospital admissions, all ages	24-hr mean*	1.0115	1.018	1.0245	All	HRAPIE 2013	
	PM2.5	Cardiovascular disease hospital admissions, all ages	24-hr mean*	1.0017	1.0091	1.0166	All	HRAPIE 2013	
	PM2.5	Respiratory disease hospital admissions, all ages	24-hr mean*	0.9982	1.019	1.0402	All	HRAPIE 2013	

Table 3.2.3: Baseline disease and mortality rates used in air pollutant health impact calculation

Health outcome	Pollutant	Rate	Units	Source	Notes
Mortality	NO_2	1,329.9	Per 100,000 population	Nomis - Official Census and Labour Market Statistics - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)	All natural-cause mortality, age 30+
	$PM_{2.5}$				
Respiratory disease hospital admissions	NO_2	657.4	Per 100,000 population	Hospital Admitted Patient Care Activity, 2021-22: Diagnosis - NHS Digital	Primary Diagnosis Summary, Emergency admissions (column H), ICD10 codes J00-J99. National data.
	$PM_{2.5}$			Local Health - OHID	T3 – Disease and Poor Health. Emergency hospital admissions for COPD. Used for Local Authority level data and adjusted using national NHS Digital data.
Cardiovascular disease hospital admissions	$PM_{2.5}$	774.4	Per 100,000 population	Hospital Admitted Patient Care Activity, 2021-22: Diagnosis - NHS Digital	Primary Diagnosis Summary, Emergency admissions (column H), ICD10 codes I00-I99. National data.
				Local Health - OHID	T3 – Disease and Poor Health. Emergency hospital admissions for CHD. Used for Local Authority level data and adjusted using national NHS Digital data.

3.3 Noise

3.3.1 **ES Chapter 14: Noise and Vibration** (Doc Ref. 5.1) has predicted changes in noise exposures, air noise, ground noise and surface access noise, at sensitive receptor locations in the study area around the airport for the relevant assessment years.

3.3.2 Noise health impacts have been calculated for the population at each receptor location using the following equation and then summed to give the net total impact for each health outcome.

3.3.3 The quantitative health analysis formula (PHE, 2014) applied to noise is as follows:

$$AB = \frac{RR_{dB} - 1}{RR_{dB}} \times P \times B$$

3.3.4 Where the relative risk of a change in a given noise exposure (RR_{dB}) is given by the formula:

$$RR_{dB} = 1 + \left((CRF - 1) \times \frac{dB}{10}\right)$$

3.3.5 Where:

- AB is the attributable burden of a specific health outcome in a given population that is identified as due to a specific exposure.
- P is the population size exposed. The cumulative population count within a given noise contour.
- B is the baseline annual rate of health outcome per person
- RR_{dB} is the relative risk of a change in a given noise exposure.
- CRF is the concentration response functions which are derived from the scientific literature. CRF is per 10 dB.
- dB is the noise level change (from the ES Noise assessment model), which allows the calculation of the relative risk for a given change in exposure other than 10 dB.

3.3.6 Acknowledging that dB is a logarithmic scale, the RR_{dB} calculation assumes a linear relationship between the change in dB and the CRF. The general linear relationship formula set out by PHE has therefore been used (PHE, 2014). This is consistent with the view that, for the purposes of analysis, there is a steady increase in risk with increasing noise level over the range of exposure (European Commission, 2013).

3.3.7 For information CRFs used at PEIR are listed in Table 3.3.1. The results using those CRFs has been provided to stakeholders in the PEIR based on the same underlying noise model results.

3.3.8 The CRFs used by the ES are listed in Table 3.3.2Table 3.3.2. These have been used to predict health outcomes arising from the change in noise exposure for the residential population. These have been derived from the health evidence base. The ES CRFs in Table 3.3.2Table 3.3.2 represent the most methodologically robust estimates, for example the analysis formula (PHE, 2014) is intended to be used with incidence rates, so these have been used in preference to prevalence rates.

3.3.9 Additional CRFs considered are listed in Table 3.3.3. Although some of these are more recent, the more conservative (larger effect size) options have been used, as set out in Table 3.3.2. Table 3.3.3 also includes CRFs that are not applicable to input into the analysis formula (PHE, 2014) agreed with the Health Topic Working Group.

3.3.10 The selection and range of CRFs in Table 3.3.2 is considered proportionate for an EIA estimation of the scale of change in noise related health outcomes due to a project. Additional quantification, including WebTAG sleep disturbance and annoyance (amenity), as well as a physiological sleep disturbance assessment is reported in **ES Chapter 14: Noise and Vibration** (Doc Ref. 5.1).

3.3.11 The baseline annual rates of health outcome are listed in Table 3.3.4Table 3.3.4.

3.3.12 The health impact assessment of noise change is based on CRFs for statistical risks applicable to a large exposed population. Although the changes in noise at most individual receptors over the relevant day and night averaging periods are likely to be small, collectively they may be associated with measurable health outcomes. It should be noted that the probability-based risk factor approach cannot predict effects for particular individuals.

3.3.13 The health evidence and metrics available mean that it is difficult to establish a single preferred health outcome to quantify, and so a range of health outcomes have been used. In some cases these overlap (eg stroke and IHD are potential outcomes of hypertension), and they should not be summed. Rather, they provide a range of effect estimates, to inform the scale of change of likely health effects due to the Project.

Table 3.3.1: Noise exposure-response metrics used at PEIR 2021

Health outcome	Low CRF	Central CRF	High CRF	Source
Hypertension prevalence A (road)	1.02	1.06	1.10	Defra and IGCB(N), 2014; Houthuijs et al., 2014
Hypertension prevalence B (aircraft)	1.00	1.11	1.23	EEA, 2010
Stroke incidence and mortality	1.00	1.04	1.09	Houthuijs et al., 2014
IHD incidence	1.04	1.08	1.13	Babisch, 2014
IHD incidence and mortality	1.01	1.05	1.09	Vienneau et al., 2015
Dementia incidence	0.86	1.48	2.55	Harding et al., 2013 (only for people with Stage-1 high blood pressure, systolic pressure of 140 to 159, so linked to hypertension risk). Applied to 'hypertension' population in analysis.
Depression prevalence	1.40	1.64	1.91	Beutel et al., 2016 (Figure 1, average of odds ratios for people who reported strong annoyance and extreme annoyance, then converted to RR). Applied to 'highly annoyed' population in analysis.

Table 3.3.2: Noise exposure-response metrics used at ES 2023

Health outcome	Low CRF	Central CRF	High CRF	Source
Stroke incidence	1.00	1.04	1.09	Houthuijs et al., 2014
IHD incidence	1.04	1.09	1.15	WHO, 2018 (Table 29)
IHD mortality	1.01	1.05	1.09	Vienneau et al., 2015
Depression incidence (aircraft)	1.19	1.23	1.28	Seidler et al., 2017 Air craft noise. Based on insurance claims and prescription data. Population is 40 years or older. Data is provided as an odds ratio, which could be converted to a relative risk if non-exposed prevalence is reported in the study, but it is not. As an approximation, national prevalence of depression is around 10% which gives a central RR of 1.20 (compared to an odds ratio of 1.23). Using the odds ratio is therefore conservative.

Table 3.3.3: Other noise exposure-response metrics the ES 2023 assessment had regard to

Health outcome	Low CRF	Central CRF	High CRF	Source	Exposure
Incidence of hypertension A	0.90	0.97	1.05	WHO, 2018 (Table 9)	L_{den} road noise (non-significant) (quality low)
Incidence of hypertension B	0.77	1.00	1.30	WHO, 2018 (Table 29)	L_{den} aircraft noise (non-significant) (quality moderate)
Incidence of hypertension	0.99	1.13	1.28	Chen, 2021	Not transport specific, covers both living and working environments.
Stroke incidence	0.96	1.05	1.15	WHO, 2018	L_{den} aircraft noise (quality very low)
Stroke incidence	1.00	1.04	1.06	Fu, 2022	Not transport specific, moderate strength of evidence using GRADE.
Stroke incidence	1.02	1.06	1.11	Hao, 2022	UK longitudinal study and meta-analysis.
IHD incidence	1.01	1.08	1.15	WHO, 2018 Rojas-Rueda, 2021	L_{den} road traffic (quality high)
IHD mortality	0.97	1.04	1.12	WHO, 2018	L_{den} aircraft noise (quality very low)
Dementia incidence	-	-	-	Zhao, 2021	Non-significant association between noise and dementia.
Depression incidence	1.02	1.12	1.23	Hegewald, 2020	Meta-analysis of 5 aircraft studies (but a non-significant effects for road noise).
Dementia Incidence	1.19	1.21	1.24	Cantuaria et al., 2021	L_{den} road traffic noise. L_{den} min 50-55 dB has been used as a worst case. Population is over 60 years.

Health outcome	Low CRF	Central CRF	High CRF	Source	Exposure
Depression Incidence	1.10	1.17	1.25	Seidler et al., 2017	Road traffic noise, odds ratios. Based on insurance claims and prescription data. Population is 40 years or older.
Self-Reported Sleep Disturbance in Adults (Noise Source Not Specified)	0.54	1.17	1.81	Basner and McGuire, 2018	L_{night} (outdoor) aircraft noise (quality very low). Table 13. Odds ratio.
Sleep disturbance (noise source not specified)	1.20	1.52	1.93	Smith, Cordoza & Basner, 2022	L_{night} aircraft noise (quality low to very low). Table 5. Odds ratio.
Children's reading score	-0.012	-0.007	-0.001	Clark et al., 2021	Aircraft noise and children's reading comprehension and hyperactivity based on a reanalysis of the Heathrow school studies. Reading score, **not** a risk ratio
Children's hyperactivity score	0.007	0.017	0.028	Clark et al., 2021	

Table 3.3.4: Baseline disease and mortality rates used in noise health impact calculation

Health Outcome	Rate	Units	Source	Notes
Stroke incidence rate	116.1	Per 100,000 population	Hospital Admitted Patient Care Activity, 2021-22: Diagnosis - NHS Digital	Primary Diagnosis 3 Character, Emergency admissions (column M), ICD codes I61, I63 and I64. National data
			Local Health - OHID	T3 – Disease and Poor Health. Emergency hospital admissions for stroke. Used for Local Authority level data and adjusted using national NHS Digital data.
Stroke mortality rate	32.9	Per 100,000 population	Nomis - Official Census and Labour Market Statistics - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)	
Ischaemic Heart Disease (IHD) incidence rate	172.5	Per 100,000 population	Hospital Admitted Patient Care Activity, 2021-22: Diagnosis - NHS Digital	Primary Diagnosis Summary, Emergency admissions (column H), ICD10 code I20-25. National data
			Local Health - OHID	T3 – Disease and Poor Health. Emergency hospital admissions for CHD. Used for Local Authority level data and adjusted using national NHS Digital data.
IHD mortality rate	68.6	Per 100,000 population	Nomis - Official Census and Labour Market Statistics - Nomis - Official Census and Labour Market Statistics (nomisweb.co.uk)	
Depression incidence	1.5%	Percentage of population	NHS West Sussex CCG - QOF Database (via OHID fingertips)	

4 Assumptions and Limitations of the Assessment

4.1.1 The health and wellbeing assessment partially draws from and builds upon, the technical outputs from inter-related technical disciplines, namely: **ES Chapter 8: Landscape, Townscape and Visual Resources** (Doc Ref. 5.1); **ES Chapter 10: Geology and Ground Conditions** (Doc Ref. 5.1); **ES Chapter 11: Water Environment** (Doc Ref. 5.1); **ES Chapter 12: Traffic and Transport** (Doc Ref. 5.1); **ES Chapter 13: Air Quality** (Doc Ref. 5.1); **ES Chapter 14: Noise and Vibration** (Doc Ref. 5.1); **ES Chapter 17: Socio-economic Effects** (Doc Ref. 5.1); and **ES Chapter 19: Agricultural Land Use and Recreation** (Doc Ref. 5.1).

4.1.2 As a consequence, the assumptions and limitations of those assessments also apply to any information used in this chapter (eg for modelling work undertaken). It is, however, considered that the information available provides a suitable basis for assessment.

4.1.3 Baseline data includes indicators where the available public data is pre COVID-19, or that have yet to show the full impacts of the pandemic for public health. The baseline has also been prepared at a time when census 2011 data is gradually being updated by releases of 2021 data. The baseline is however considered sufficient and robust in evidencing that there are vulnerable population groups with high sensitivity. New data would be unlikely to change that conclusion and as a 'high' sensitivity is already assigned to vulnerable groups, would not change the assessment.

4.1.4 The quantitative analyses undertaken use formulae and coefficients developed to be applied to large populations to inform strategic level decisions about policies to bring about large exposure reductions. These are being applied as part of a project level assessment to small scales of exposure change for relatively small populations. The error margins on analysis outputs are therefore likely to be wide and should be treated as being indicative of the scale of change, eg the order of magnitude, rather than precise estimates of health outcomes.

4.1.5 Inherent to the health quantitative analysis is that the input data from **ES Chapter 13: Air Quality** (Doc Ref. 5.1) and **ES Chapter 14: Noise and Vibration** (Doc Ref. 5.1) itself has error margins, as well as the health quantitative analysis also having error margins. That the error margins from the two stages of quantification both contribute to the overall error margins of the analysis is acknowledged. The health outcomes quantified are only intended to be used to indicate the scale of change due to the Project, not precise predictions of actual health outcome changes. The overall error margins are not quantified, but ranges based on the confidence intervals reported in the scientific literature for CRFs are included in **Appendix 18.8.1: Quantitative Health Assessment Results** (Doc Ref. 5.3). The results of the health quantitative analysis are reported to a number of decimal places to aid interpretation of the scale of change. Where several decimal places are used this is likely to go beyond model accuracy, but as noted, the use of the quantification is only to demonstrate the scale of change, which is best illustrated at times though multiple decimal places.

4.1.6 All decision making is within the context of imperfect information and therefore uncertainty. Reducing uncertainty is a key element of impact assessment. Whilst not all uncertainty can be removed, the following steps have been taken to allow confidence in the EIA health assessment conclusions:

- Methods are used that triangulate evidence sources and professional perspectives.
- The scientific literature reviews undertaken give priority to high quality study design, such as systematic reviews and meta-analysis, and strength of evidence.
- Quantitative inputs for other assessments have been used, which included model validation, as described in other chapters.
- The health assessment has been cautious, with conservative assessments, for example in taking account of non-threshold effects and vulnerable group findings.
- Monitoring is included as appropriate.
- The health assessment has been transparent in its analysis and follows good practice.

5 References

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