

ESTIMATES OF THE BURDEN OF DISEASE DUE TO TRANSPORTATION NOISE IN ENGLAND

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1 INTRODUCTION

Parts of this article are taken from Jephcote C, Clark SN, Hansell AL, et al. Spatial assessment of the attributable burden of disease due to transportation noise in England. Environment International 2023;107966¹, in which Sierra Clark and Benjamin Fenech were joint first and senior authors, respectively.

Long-term exposure to environmental noise can have a negative impact on psychological and physiological health^{2,3}. Health-based guidelines for environmental noise published by the World Health Organization (WHO) Regional Office for Europe were 53 dB L_{den} for road, 54 dB L_{den} for railway, and 45 dB L_{den} for aircraft noise (WHO ENG 2018). In the UK there are approximately 11.5 million people exposed to noise above 55 dB L_{den} from major roads⁴. Environmental burden of disease assessment approaches allow for the estimation of the health impacts and burden attributable to noise within a society exposed to an environmental risk factor. This can then be used to help guide public health decision-making and planning⁵. The Disability Adjusted Life Year (DALY) lost is a metric that is often used to quantify the burden of disease in a society from both morbidity and mortality. It combines the years of life lost due to premature death and years of life lived in less than full health within a population.⁶

Environmental burden of disease estimates can have significant influence on central and local government decision making and public health interventions. Therefore, understanding the degree of uncertainty is essential for proper health risk communication. Environmental burden of disease quantifications depend on a variety of input variables and assumptions related to exposures, exposure-health relationships, and underlying disease incidence and burden, and estimates can be highly sensitive to some of these inputs/assumptions. Estimates of DALYs attributable to noise can therefore vary depending on the noise modelling methodology and the exposure response relationships (ERRs) used. Where alternative scientifically-robust information on any inputs/assumptions exist, it is important to understand their impacts on the overall estimates.

Here, we summarise the main findings from Jephcote et al. (2023)¹. We also present some of the original sensitivity analyses examining the impact of using alternative noise modelling techniques and ERRs, and new sensitivity analyses in relation to using ERRs for aviation noise annoyance derived from a UK socio-acoustic study.

2 METHODS

2.1 Environmental burden of disease approach

We calculated DALYs as a measure of the burden of disease attributable to noise exposures from road, rail, and civil airports in England at the national level using established epidemiological methodologies⁷. Our estimates are based on population demographic and health data for the year 2018, and noise exposure distributions based on noise mapping carried out for the year 2012.

2.2 Geography and population

We conducted the analysis in England. Geographic boundaries for nine regions and 314 Local Authority Districts (LAD) were obtained from the UK Office of National Statistics (licensed under the Open Government Licence v.3.0; contains OS data © Crown copyright and database right)⁸. As the majority of the evidence of the health effects of noise is from cohort studies with adult subjects, we

limited the analysis to the adult population normally resident in England (20 + years, $n = 42,738,500$) in 2018⁹.

2.3 Road, railway, and aircraft traffic noise exposure data

We utilized the 2012 noise exposure datasets for road, rail, and aircraft sources generated by the 'Round 2 (II)' strategic noise mapping to fulfil the requirements of the Environmental Noise (England) Regulations 2006 (ENR)¹⁰. For road traffic, exposure was assessed via a single national exposure dataset produced by combining:

- exposure to major sources (defined as a trunk road, or a motorway, or a principal or classified road that has more than three million vehicle passages a year), for receptors outside agglomerations⁴, with
- exposure to all motorways and classified (A roads) roads, for receptors living within agglomerations.

The datasets also included noise exposure from:

- Major railways: railways that record >30,000 train passages per year
- Major airports: civil airports, which record >50,000 movements per year (a movement being a take-off or a landing), excluding those purely for training purposes on light aircraft.

The 'Round 2 (II)' strategic noise maps of England and the associated residential population exposure assessment were produced by Extrium environmental consultants under contract to the UK Department for Environment, Food & Rural Affairs (DEFRA). The 'Round 2 (II)' noise mapping data production and exposure assessment process is known to be based on input data which had a high degree of currency consistency. This included road and rail transport movements; Ordnance Survey topographic data, e.g., the locations of buildings, noise barriers and transport infrastructure; Ordnance Survey address data and the 2011 Census. Source specific exposures were modelled for the façade of a building that faces the nearest major noise source, which is theoretically the point of maximum exposure. Population level exposures were then calculated for the 2011 Census Output Area (COA) communities. Residential buildings were identified from postal addresses, categorised into 1 dBA increments of L_{den} and L_{night} noise levels ranging from 50 dB to ≥ 80 dB, and then population counts were evenly assigned to the households. We then estimated LAD population exposures to noise in 2018 by applying the noise mapping exposure distributions to population counts recorded in 2018 by LAD. Doing this, we assumed that (i) the contribution and spatial distribution of major noise sources remained temporally stable between 2012 and 2018, and (ii) exposure distributions were the same for all age groups. By using the 'Round 2 (II)' noise level data and the exposure assessment model (rather than the more recent 2017 'Round 3 (III)' strategic noise mapping), we had access to the underlying noise exposures in 1 dB bands and data starting at 50 dB for both L_{den} and L_{night} . END exposure data in the public domain a) is in 5 dB bands, and b) starts from 55 dB L_{den} . Whilst road and railway noise exposure distributions are expected to be relatively stable over a period of six years, our assumptions may have introduced uncertainties for the aircraft noise estimates, due to growth in the aviation sector¹¹, replacement of older noisier aircraft types with more modern quieter ones¹² and potential changes to flightpaths¹³ and operational procedures during this period.

The population data was sourced from NOMIS, the Official Labour Market Statistics service provided by the Office for National Statistics (ONS)⁹ and was based on adult persons normally resident in English Local Authority Districts in 2018.

2.4 Health outcomes

Following a systematic review of reviews¹⁴, we selected health outcomes based on the strength of the epidemiological and mechanistic evidence¹⁵ of the health effects of noise. The health outcomes

included: annoyance (highly annoyed (HA))^{2 16}, sleep disturbance (highly sleep disturbed (HSD))^{17 18}, IHD (also referred to as coronary heart disease)^{19 20}, stroke^{19 21}, and diabetes^{20 22}. We only considered relative risks (RR) that were statistically significant, and which were associated with a specific traffic source (road, rail, or aircraft as opposed to 'total noise'). We did not calculate attributable burden of disease for railway noise and IHD, stroke, and diabetes, as well as aircraft noise and stroke and diabetes. ERRs for main estimates are shown in Table 1.

To estimate the proportion of all new cases of disease, or other adverse condition, in a population that is attributable to a specific exposure^{7 23}, we calculate Population Attributable Fractions (PAF). To calculate a PAF, the exposure distribution within a population, as well the relative risk of disease due to exposure, must be known. See Jephcote et al.¹ for further details.

The percentage of the population highly annoyed and highly sleep disturbed within LADs was estimated directly from the quadratic exposure–response function equations derived by the WHO-commissioned systematic reviews and subsequent updates. We calculated the number of highly annoyed and highly sleep disturbed adults by multiplying the number of adults within each 1 dB noise band above 50 dB L_{den} (HA) and L_{night} (HSD) by the percentage of highly annoyed and highly sleep disturbed individuals at the corresponding noise level.

2.5 Noise burden of disease

Our main measure of disease burden was the Disability Adjusted Life Year (DALY). The DALY simultaneously considers the reduced health state due to disability before death (Years of Life Lived with Disability (YLD)) and the decline in life expectancy due to death (Years of Life Lost (YLL)). We estimated DALYs for LADs represented as total DALYs as well as DALY rates per 100,000 people to adjust for local population sizes. See Jephcote et al.¹ for further details.

As a final step, the noise attributable DALYs were estimated by multiplying the PAF (i.e., disease attribution to noise) by the DALY (i.e., disease burden). The noise attributable DALYs were estimated with respect to each noise source (road, railway, aircraft) and health outcome separately at the LAD level. The calculation procedure for annoyance and sleep disturbance followed a slightly different process, whereby the number of adults highly annoyed and sleep disturbed were multiplied by the corresponding disability weight to estimate the attributable DALYs.

2.6 Sensitivity analysis

2.6.1 Alternative road-traffic noise exposure distributions: Case-study applied to the London region

Our main analysis quantified the attributable burden of disease for the adult population in England exposed above 50 dB L_{den} and L_{night} from road, railway, and aviation (commercial airports) sources, based on noise modelling conducted to fulfil the ENR strategic noise mapping requirements. However, we are likely under-estimating the attributable burden of disease due to the (i) restricted exposure range (>50 dB L_{den} and L_{night}) and because (ii) exposures from “minor” roads (i.e., collector, residential and local access roads) are not taken into account. Therefore, we conducted a sensitivity analysis where the attributable burden of disease was estimated with an alternate exposure distribution derived from all road sources (CNOSSOS-all roads model) and with a wider exposure range, starting at 40 dB L_{den} and 35 dB L_{night} . We conducted this analysis for the London region only, due to the availability of data. The exposure estimates were created by the Centre for Environmental Health and Sustainability (CEHS) at the University of Leicester, using a road-transport noise model for 2013²⁴ in accordance to the European Commissions ‘Common framework for noise assessment’ (CNOSSOS)²⁵.

Table 1. Parameters used for the central estimates of burden of disease attributable to transportation noise for the adult population in England in 2018. Reprinted from Jephcote et al.¹

	Health outcome	Noise metric	ERR source	ERR function/relative risk estimate [95% confidence interval]	ERR lower	ERR upper	Disability weight [95% confidence interval <i>if available</i>]
Road	Highly annoyed	L _{den}	26 *	%HA = 116.4304 - 4.7342 × L _{den} + 0.0497 × L _{den} ² <i>Excluding Asian and Alpine studies</i>	40 dB	80 dB	0.02 ²⁷
	Highly sleep disturbed	L _{night}	28 **	%HSD = 31.18323 – 1.47351 × L _{night} + 0.01851 × L _{night} ²	40 dB	65 dB	0.07 ²⁹
	Ischemic heart disease	L _{den}	30	1.08 [1.01-1.15] per 10 dB	53 dB	80 dB	0.405 ³¹
	Stroke	L _{den}	30	1.14 [1.03-1.25] per 10 dB	50 dB	70 dB	0.522 [0.377-0.707] ³²
	Diabetes mellitus	L _{den}	22	1.07 [1.02-1.12] per 5 dB	50 dB	80 dB	0.049 [0.031-0.072] ³³
Railway	Highly annoyed	L _{den}	26	%HA = 38.1596 – 2.05538 × L _{den} + 0.0285 × L _{den} ²	40 dB	85 dB	0.02 ²⁷
	Highly sleep disturbed	L _{night}	28**	%HSD = 63.56140 – 3.00711 × L _{night} + 0.03717 × L _{night} ²	40 dB	65 dB	0.07 ²⁹
Aircraft	Highly annoyed	L _{den}	26	%HA = -50.9693 + 1.0168 × L _{den} + 0.0072 × L _{den} ²	40 dB	75 dB	0.02 ²⁷
	Highly sleep disturbed	L _{night}	28**	%HSD = 17.07421 – 1.12624 × L _{night} + 0.02502 × L _{night} ²	40 dB	65 dB	0.07 ²⁹
	Ischemic heart disease	L _{den}	30	1.09 [1.04-1.15] per 10 dBA	47 dB	75 dB	0.405 ³¹

ERR: Exposure response relationship; ERR lower: Lowest noise level (counterfactual) at which the ERR is valid; ERR upper: Highest noise level at which the ERR continues to increase *WHO commissioned systematic review derived two ERR curves for highly annoyed due to road-traffic noise exposure. One curve utilizing the full WHO dataset and another excluded Asian and Alpine studies ²⁶. **Smith et al presented multiple curves for HSD. We used the ‘combined estimate’ where noise was explicitly mentioned in the question ²⁸.

2.6.2 Alternative road-traffic and railway noise exposure response relationships for noise annoyance

We conducted a series of sensitivity analyses with alternative ERRs which either reflected an update to the evidence base or the consideration of study context and inclusion in ERRs for noise annoyance. These included:

- ERR proposed by Guski et al² which used the full WHO dataset and included studies published up until 2014.
- ERRs for road-traffic and railway noise proposed by Fenech et al¹⁶ which updates the evidence from the WHO-commissioned systematic reviews by including studies published up until 2022.

2.6.3 Alternative aircraft-traffic noise exposure response relationships for noise annoyance from SoNA 2014

The WHO ENG 2018 acknowledged that for noise annoyance there is often considerable heterogeneity in effect sizes of studies, because estimates are to some degree dependent on the situation and context, including cultural differences around what is considered annoying. The Guidelines therefore recommended that data and exposure-response curves derived in a local context should be applied whenever possible to assess the specific relationship between noise and annoyance in a given country/context.

There has been no recent large-scale socio-acoustic study for road and railway noise in the UK since 1984¹⁶. For aviation noise a Survey of Noise Attitudes (SoNA) 2014³⁴ was conducted between October 2014 – February 2015. A total of 1,999 respondents aged 18 years and over and living in proximity to nine of the largest airports in England completed face-to-face interviews. Of these, 122 were excluded from analyses as they were not resident at their addresses during summer 2014, resulting in a sample size of 1,877. Airplane noise exposure for their properties was estimated using noise contours around each of the nine airports.

SoNA included three questions about aviation noise annoyance that can be used to derive an ERR for highly annoyed^{34 35}. They are reproduced here in order of appearance on the survey:

Question A9a: Thinking about the last 12 months or so, when you are here at home, how much does noise from aircraft, airports or airfields, bother, disturb or annoy you? (five point scale from not at all, slightly, moderately, very, extremely).

Question CAN1i: So, thinking about this summer, when you were here at home, how much did each of these different types of noise from aeroplanes bother, disturb or annoy you? (five point scale from not at all, slightly, moderately, very, extremely).

Question CAN34: Thinking about this summer, what number from 0 to 10 best shows how much you were bothered, disturbed or annoyed by noise from aeroplanes (eleven point scale, 0 = not at all, 10 = extremely).

Data from SoNA 2014 therefore offers an England specific alternative for modelling ERRs for being highly annoyed by aircraft noise. For the 11-point numerical scale (CAN34), highly annoyed is typically defined as the top three answers (answers 8-10)^{36 37}, corresponding to a cut-off point of 72% of total scale length. For the two five-point verbal scales (A9a and CAN1i), two approaches to defining highly annoyed are recognised as valid according to the relevant ISO Technical Specification³⁶. The first definition uses the top two verbal response categories (very and extremely) to define highly annoyed. This approach yields a cut-off of 60% of total scale length. A second approach was proposed by Miedema & Vos³⁸ to mimic the 72% cut-off of the numeric scale, where highly annoyed is defined as the top two verbal response categories with 'extremely' counted in full and 'very' being weighted by a factor of 0.4. However some large-scale studies^{39 40} have shown that this approach does not necessarily result in congruent ERRs.

We used similar logistic regression methods as reported in the original SoNA report³⁴ to generate ERRs between aircraft noise exposure $L_{Aeq,16hr}$, and the likelihood of being highly annoyed, based on responses to A9a, CAN1i and CAN34. Highly annoyed was the binary dependent variable and $L_{Aeq,16hr}$ was the predictor variable. For the questions using a verbal scale (A9a and CAN1i), we modelled ERRs using the unweighted (60% cut-off) and weighted (72% cut-off) definitions of highly annoyed. For CAN34, the cut-off is 72%.

3 Results

3.1 Main analysis

Forty percent of the adult population in England were exposed to road-traffic noise from major sources that exceeded 50 dB L_{den} . Road-traffic accounted for the majority of the DALYs lost in England in 2018, accounting for close to 97,000 DALYs/yr (Table 2). This was followed by aircraft (~17,000/yr) and then railway (~13,000/yr) noise exposures. Across health outcomes, annoyance accounted for the largest number of total DALYs/yr from road-traffic (33,243/yr) and aircraft (10,486/yr) exposures, while sleep disturbance accounted for the most from railway noise exposures (7,127/yr).

Table 2. Attributable burden of annoyance, sleep disturbance, ischemic heart disease, stroke, and diabetes mellitus due to road-traffic, railway, and aircraft noise exposures above 50 dB L_{den} and L_{night} in England. Reprinted from Jephcote et al.¹

		Road-traffic Central estimate [95 % confidence interval]*	Railway traffic Central estimate [95 % confidence interval]*	Aircraft traffic Central estimate [95 % confidence interval]*
Highly annoyed (HA)	% of population	3.9	0.7	1.2
	Number of people	1,662,157	295,766	524,321
	Total DALYs/yr	33243	5,915	10,486
	DALYs per 100,000 people/yr	78	14	25
Highly sleep disturbed (HSD)	% of population	09. [0.6 – 1.2]	0.2 [0.2 – 0.3]	0.2 [0.1 – 0.2]
	Number of people	382,333 [236,040 – 521,004]	101,815 [66,788 – 127,132]	65,455 [47,155 – 83,625]
	Total DALYs/yr	26,763 [16,523 – 36,470]	7,127 [4,675 – 8,899]	4,582 [3,301 – 5,854]
	DALYs per 100,000 people/yr	63 [39 – 85]	17 [11 – 21]	11 [8 – 14]
Ischemic heart disease (IHD)	PAF (%)	1.5 [0.2 – 2.7]	-	0.2 [0.1 – 0.4]
	Total DALYs/yr	11,556 [1,427 – 21,942]	-	1,970 [876 – 3,273]
	DALYs per 100,000 people/yr	27 [3 – 51]	-	5 [2 – 8]
Stroke	PAF (%)	3.8 [0.8 – 6.6]	-	-
	Total DALYs/yr	18,529 [2,926 – 41,093]	-	-
	DALYs per 100,000 people/yr	44 [7 – 96]	-	-
Diabetes Mellitus	PAF (%)	4.2 [1.2 – 7.2]	-	-
	Total DALYs/yr	6,686 [1,291 – 16,301]	-	-
	DALYs per 100,000 people/yr	16 [3 – 38]	-	-

Total DALYs/yr: Total number of Disability Adjusted Life Years lost per year; YLL: Years of Life Lost; YLD: Years of Life Lived with Disability; PAF (%): Population Attributable Fraction percentage (%); % of pop: Percentage of the population.

*We did not have 95% confidence intervals for the exposure-response relationships to be able to construct a 95% confidence interval around the burden of disease estimate.

3.2.1 Sensitivity analyses 1: Alternative road-traffic noise exposure distributions

As a sensitivity analysis for the noise exposure modelling, the attributable burden of disease for London was estimated using an alternative noise exposure distribution that includes all roads (*CNOSSOS-All roads*). Within London we estimated a higher number of attributable DALYs/yr with *CNOSSOS-All roads* compared with *ENR strategic mapping*. The relative increase in attributable DALYs/yr varied between health outcomes, ranging from 1.1x (IHD) to 2.2x (HSD) times higher (Table 3). As such, we are likely underestimating the road-traffic noise attributable burden of disease in England using noise exposure modelling from the 2nd round of strategic noise mapping in England.

Table 3. Comparison of the impact of modelled noise exposure distributions on the road-traffic attributable burden of disease in London. Reprinted from Jephcote et al.¹

Health outcome		Road-traffic: strategic mapping (<i>ENR</i>)*	Road-traffic: all roads (<i>CNOSSOS-All roads</i>)**	Relative increase (<i>CNOSSOS-All roads</i> compared with <i>ENR</i>)
		≥50 dBA L _{den} ≥50 dBA L _{night}	≥40 dBA L _{den} ≥35 dBA L _{night}	
Highly annoyed (HA)	% of population	5.8%	8.0%	1.38x higher
	Number of adults	388,389	534,467	
	Total DALYs/yr	7,768	10,689	
Highly sleep disturbed (HSD)	% of population	1.4%	3.2%	2.21x higher
	Number of adults	96,501	213,723	
	Total DALYs/yr	6,755	14,961	
Ischemic Heart Disease (IHD)	PAFs	2.3%	2.5%	1.09x higher
	Total DALYs/yr	1,886	2,057	
Stroke	PAFs	5.5%	6.9%	1.27x higher
	Total DALYs/yr	2,623	3,330	
Diabetes mellitus	PAFs	5.9%	7.3%	1.23x higher
	Total DALYs/yr	1,381	1,704	

ENR*: Noise exposures derived from modelling to fulfil the ENR Round 2 strategic mapping requirements (main analysis). *CNOSSOS-All roads*: Noise exposures created by the Centre for Environmental Health and Sustainability at the University of Leicester in accordance with CNOSSOS-EU modelling framework²⁴.

3.2.2 Sensitivity analyses 2: Alternative road-traffic and railway noise exposure response relationships for noise annoyance

Results from sensitivity analyses two are shown in Table 4. By applying alternative road-traffic ERRs, we found that the number of DALYs/yr were 1.4x (Guski et al.²) and 1.3x (Fenech et al.¹⁶) times higher than our main estimate. For railway noise, the alternative ERR for annoyance resulted in a smaller difference (1.15x times higher than our main estimate).

Table 4. Attributable burden of disease (noise annoyance only) due to road-traffic and railway-traffic noise exposure using alternative exposure response relationships (ERR) for annoyance. Reprinted from Jephcote et al.¹

Source of ERR	% of population highly annoyed	Number of people highly annoyed	Total DALYs/yr
Road-traffic noise (≥ 50 dBA L_{den})			
Main ERR (Guski et al. 2017) <i>WHO Excl. Asian and Alpine *</i>	3.9	1,662,157	33,243
Sensitivity ERR (Guski et al. 2017) <i>WHO full dataset **</i>	5.4	2,311,990	46,917
Sensitivity ERR (Fenech et al. 2022) <i>2022 update ***</i>	5.1	2,195,850	43,917
Railway-Traffic noise (≥ 50 dBA L_{den})			
Main ERR (Guski et al. 2017) <i>WHO full dataset ****</i>	0.7	295,766	5,916
Sensitivity ERR (Fenech et al. 2022) <i>2022 update *****</i>	0.8	341,849	6,837

3.2.3 Sensitivity analyses 3: Alternative aircraft-traffic noise ERR for annoyance

Results for highly annoyed by aircraft noise using SoNA data are shown in Table 5. The combination of three annoyance questions and two alternatives for deriving high annoyance from the verbal scale (A9a, CAN1i) give five sets of results. The highest attributable burden from annoyance resulted from question A9a (verbal scale) using a 60% cut-off to calculate high annoyance. The lowest attributable burden was obtained using CAN34 (numeric scale, 72% cut-off). The attributable burden of aviation noise annoyance using the SoNA2014 data is 25-50% of that estimated using the aggregated ERR proposed in the WHO Environmental Noise Guidelines (2018).²

Table 5. Comparison of the impact of ERR selection on Burden of Disease (High Annoyance) from aircraft noise

	Main ERR <i>Guski et al. 2017</i> ≥ 50 dB L_{den}	Sensitivity ERR <i>SoNA A9a</i> ≥ 50 dB $L_{Aeq,16hr}$	Sensitivity ERR <i>SoNA CAN1i</i> ≥ 50 dB $L_{Aeq,16hr}$	Sensitivity ERR <i>SoNA CAN34</i> ≥ 50 dB $L_{Aeq,16hr}$
ERR HA cut-off	n/a	60%	60%	-
% of population	1.2	0.63	0.58	-
Number of people	524,321	267,433	245,896	-
Total DALYs/yr	10,486	5,349	4,918	-
DALYs per 100,000 people/yr	25	13	12	-
ERR HA cut-off		72%	72%	72%
% of population	-	0.42	0.39	0.33
Number of people	-	180,491	168,083	140,057
Total DALYs/yr	-	3,610	3,362	2,801
DALYs per 100,000 people/yr	-	8	8	7

4 Discussion

Estimating burden of disease attributable to transportation noise is an important process that can guide public health decision-making and planning⁵. Such health risk assessments require a number of assumptions and data inputs, each of which will introduce variability in the results. For example, the choice of the exposure response relationships relating exposure to a specific health endpoint, and the noise modelling methodology can impact estimates of attributable DALYs lost to any given disease associated with noise pollution. In this paper we present some of the sensitivity analyses in the original analysis by Jephcote et al., and we extended these original findings by using data on aircraft noise annoyance from the SoNA 2014³⁴ survey as an example of using exposure-response relationships derived in a local context.

The availability of strategic noise mapping data greatly facilitates noise burden of disease assessments at national and regional levels. The downside is that trade-offs may have been required. For example not all roads, railways and airports may be included in the modelling, and the chosen lower noise exposure cut-offs may give an incomplete picture of population exposure in the range where health effects are known to occur. As we showed with a sensitivity analysis for London, these two factors are likely to lead to under-estimation of the attributable disease burden, and demonstrates the importance of modelling all roads, and using a lower noise exposure than 50 dB L_{den} / L_{night} . A similar result, but with even greater differences, was found for the Hessian population in Germany⁴¹.

The choice of exposure response relationship (ERR) for annoyance had an impact on attributable DALYs, as evidenced by the differences observed when applying the road-traffic curves using the full WHO dataset versus curves excluding Asian and Alpine studies^{2 16}. There was also an impact on attributable DALYs for railway-traffic noise when using an alternative ERR¹⁶. However, it was smaller than that observed for road-traffic noise.

The WHO ENG guidelines recommend that data and ERRs derived in a local context should be used wherever possible. The third set of sensitivity analyses used data on aircraft noise annoyance derived from an English survey³⁴ to examine how burden of disease estimates vary from our main estimates based on an aggregated ERR. Using SoNA data yielded considerably smaller estimates (regardless of survey question used or method to derive high annoyance) of the burden of aircraft noise annoyance when compared to estimates using the ERR presented by Guski et al. (2017)². Using ERRs derived from a local context may have some limitations – no single cross-sectional socio-acoustic study can be considered fully representative of current or future situations. Changes in noise exposure and the strengthening epidemiological evidence on the health effects of noise is likely to lead to changes in the estimates presented in this paper.

Acknowledgements

The authors would like to acknowledge the contribution of all the collaborators listed in the *Jephcote et al. (2023)* paper for some of the content reproduced in this paper. The SoNA 2014 results are from analysis of *CAP1506b SoNA 2014 Data Files (xlsx format)* published by the CAA. The authors would like to thank Dr. Darren Rhodes for his comments on the presentation of results. The views expressed are those of the authors and not necessarily those of the UK Health Security Agency, Department of Health and Social Care, or other government departments or agencies.

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