Environmental Research Consultancy Department

Aircraft Noise and Health Effects – a six-month update

CAP 3087

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Contents

Chapter 1

Introduction

1.1 This report is an update on recent work and findings in the field of aircraft noise and health effects. It covers published research between September 2024 and March 2025, and includes findings presented in published academic papers and relevant conferences during that period.

1.2 The aim of the report is to provide a succinct overview of new work relating to aviation noise and health, and such updates are published on a six-monthly basis. This report has been published to provide the public and the aviation industry with a concise and accessible update on recent noise and health developments. It should be noted that the CAA has not validated any of the analysis reported at the conferences, nor takes any view on their applicability to UK policy making.

1.3 The findings in the following chapters are grouped by subject area.

Chapter 2

Aircraft Noise and Cardiovascular Disease

2.1 Most of the papers published in the past six months have centred around the cardiovascular effects of aircraft noise. This chapter focuses on the findings in this area of research.

2.2 The first paper was by **Peters et al**, who examined the effect of long-term nighttime aircraft noise exposure on the risk of incident hypertension in female nurses. Results on hypertension, cardiovascular disease and mortality, and self-reported sleep quality from the national cohort of female nurses in the US called the Nurses' Health Study (NHS) and Nurses' Health Study II (NHSII) populations have been included in previous reports. The two Nurses' Health Study cohorts resided around 90 airports in the US.

2.3 The NHS began in 1976 and the NHSII in 1989, with the recruitment of female U.S. registered nurses. Participants were followed up every two years with a response rate of 86% overall and 90–94% among those participating over a year. The follow-up questionnaires updated information on variables such as demographic characteristics, health-related behaviours, incidence of major diseases, medical history, and residential addresses. Participants were included in the current analyses if they were alive and free of hypertension in 1994/1995 - the year the first aircraft noise estimate was available.

2.4 The authors further analysed the data from this study, this time they examined the nighttime aircraft noise and incident hypertension. Nighttime noise L_{night} (average A-weighted equivalent continuous sound pressure level from aircraft noise between 22:00 to 07:00) was used. The Day-Night (DNL) noise metric was also included to allow for direct comparison with nighttime noise within otherwise identical statistical models both including updated air pollution and socioeconomic variables. DNL is cumulative A-weighted equivalent sound level for an average 24-hour period with a 10-dB penalty added to nighttime sound levels.

2.5 Incident hypertension was assessed by a question on the follow-up phase of the study asking participants whether they had received a doctor's diagnosis of high blood pressure since the previous questionnaire was administered. The eligible participants were followed from 1994 for NHS and 1995 for NHSII to the time of hypertension diagnosis, loss-to follow up, death, or the end of the study period (2014 for NHS and 2013 for NHSII).

2.6 Three models were included in the analysis:

- basic (adjusting for age and calendar period),

- parsimonious (basic model adding race, spouse's educational attainment, physical activity, smoking status, alcohol consumption, diet, region of residence, socioeconomic status, and air pollution),
- extended model (parsimonious model adding related variables that could be potential mediators or colliders including BMI, menopausal status, family history of hypertension, and medications).

2.7 Sensitivity analysis was conducted for shift workers and hearing loss. The results of the analysis for DNL and L_{night} and hypertension risk are shown in Figure 1.

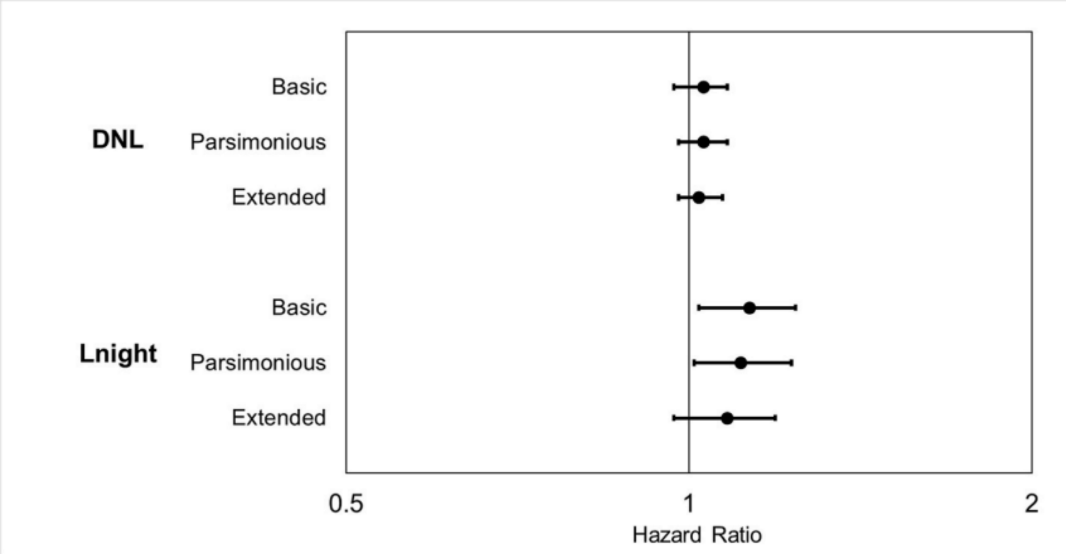

Figure 1: Results of meta-analysis (combined Nurses' Health Study (NHS) and NHSII cohorts) of noise and hypertension risk for DNL and L_{night} noise exposures comparing those exposed to ≥45 dB versus <45 dB.

2.8 Although the number of participants exposed to ≥45 dB L_{night} was lower than the number exposed to 24-hour average noise level (DNL) above 45 dB, the effect estimates of nighttime noise and hypertension were higher than those for DNL. The correlation between the two metrics was 0.79 in NHS and 0.74 in NHSII. The authors highlight this is similar to the results found in the HYENA study, which found a correlation of 0.8 for the daytime versus nighttime noise.

2.9 The authors explain that the results indicated that participants exposed to L_{night} ≥45 dB were more likely than those exposed to <45 dB to be a race other than white, live in U.S. Census areas with lower neighbourhood-level socioeconomic status, and have higher NO_2 exposure. For the 63,229 NHS and 98,880 NHSII participants free of hypertension at study baseline (1994/1995), the authors observed 33,190 and 28,255 new hypertension cases by 2014/2013, respectively. Approximately 0.67% of NHS participants and 0.91% of NHSII participants were exposed to L_{night} ≥45 dB.

2.10 The analysis for the parsimonious model revealed an adjusted hazard ratio (HR) of 1.10 for hypertension (95% CI: 0.96, 1.27) in NHS and adjusted HR of 1.12 (95% CI: 0.98, 1.28) in NHSII, comparing exposure to Lnight ≥45 versus <45 dBA. For the extended model, the HRs were 1.07 (95% CI: 0.93, 1.24) and 1.08 (95% CI: 0.94, 1.24) for NHS and NHSII, respectively. In the meta-analysis of the two cohorts, the authors found HRs in the parsimonious model of 1.11 (95% CI: 1.01, 1.23) and in the extended model 1.08 (95% CI: 0.97, 1.19). No effects of shift work, hearing loss or NO_2 were found.

2.11 The authors suggest that the stronger effects of aircraft noise on hypertension risk found for L_{night} may be due to the relationship between noise, sleep disturbance and cardiovascular effects. They propose future studies should include larger numbers of more diverse participants who are exposed to higher levels of aircraft noise than those in this study.

2.12 **Thacher et al** published findings from their study on the risk of atrial fibrillation due to transportation noise in Swedish, Danish and Finnish study populations. The study was part of the NordSOUND project ("Nordic Studies on Occupational and Traffic Noise in Relation to Disease"), the aim of which was to investigate the health-related impacts of noise.

2.13 Atrial fibrillation (AF) is an irregular heart rhythm and is one of the most common arrhythmias, with around 4% of people over the age of 50 years having this symptom. Symptoms of AF include heart palpitations, dizziness and shortness of breath and increases the risk of stroke, blood clots, and other cardiovascular issues. Risk factors include high blood pressure, coronary artery disease and obesity.

2.14 The authors explain that the current knowledge around transportation noise and the risk of AF is inconclusive. For aircraft noise, previous research in Denmark has suggested an association between high noise exposure levels and AF. Another study has suggested an effect of nighttime aircraft noise and arrhythmia, and there has also been evidence of annoyance due to aircraft noise being associated with a higher risk of AF in a German population.

2.15 For the eleven cohorts in this study, transportation noise (road, railway and aircraft) at residential addresses was calculated at the most exposed façade (L_{Aeq}) and expressed as $L_{den.}$ Over 116,000 people were included in the study, with 18,939 incident AF cases diagnosed over a median follow-up for the population of 19.6 years. Only 1.8% of the study population was exposed to aircraft noise > 50 dB L_{den}. Road traffic noise was associated with a 2% higher hazard ratio of incident AF per 10 dB higher 5-year exposure. The associations were strongest for women, and those people with a high BMI. No association between railway noise and AF incidence was observed. For aircraft noise, there was no clear association, although the authors suggested there was some evidence for an association for the >50 dB group (HR 1.12 (95% CI: 0.98–1.27), and in the group 40.1–50 dB L_{den} having HRs of 1.04 (0.93–1.16), suggesting a possible exposure-response relationship. For all three noise sources, when adjustment was made for particulate air pollution, BMI, smoking, and alcohol consumption, only very small changes of the HRs were observed. When road, railway and aircraft noise was combined, the risk of AF was higher with a HR of 1.19 (1.02–1.40), suggesting people exposed to multiple noise sources may be particularly at risk from AF.

2.16 The authors proposed that further studies on aircraft noise and AF are required, as this study suggests that aircraft noise above 50 dB L_{den} may be a contributory factor to the development of AF. They also suggest further research into the intermittency of aircraft noise and road noise and how this may be associated with the development of AF.

2.17 **Hoffman and Vienneau** commented on the Peters et al study, and reiterated that intermittency ratio of noise may affect cardiovascular health and produce a stress response even at low and medium noise levels. They argue that the results of the Peters et al study may actually be conservative, with possible effects on cardiovascular disease such as AF at lower noise levels than current guidelines state. They suggest further work is needed in order to identify (and implement) the most relevant noise exposure characteristics for safeguarding health.

2.18 **Kuntić et al** investigated the role of cardiovascular medications in noise-induced cardiovascular oxidative stress in mice. The aim was to examine whether there was a protective effect of using alpha- (phenoxybenzamine) or beta-blockers (propranolol) when exposed to aircraft noise with mean sound pressure levels of 72 dBA for 4 days.

2.19 The aircraft noise exposure in untreated mice resulted in the production of hypertension and impaired endothelial lining. Oxidative stress and inflammation markers were also increased. In the mice treated with the alpha and beta-blockers, endothelial and microvascular dysfunction was prevented. There was also a decrease of inflammatory markers and oxidative stress in the heart and brain tissue. There was no effect on blood pressure.

2.20 The authors highlighted the importance of improved endothelial function for vulnerable groups exposed to aircraft noise, for example patients with pre-established ischemic heart disease or prone to stroke and being under standard alpha- and beta-blocker therapy.

2.21 **Münzel et al** described the results of a recent umbrella+ review by one of the fellow authors that combined the evidence from the 2018 WHO Environmental Noise Guidelines, with more recent (post 2015) high-quality systematic reviews of original studies on transportation noise and cardiovascular and metabolic risk.

2.22 The review covered several areas relating to transportation and cardiovascular disease, with a main focus on road noise. For mortality, 61 studies were identified, out of which 12 prospective cohort studies on road, railway, and/or aircraft noise were eligible for meta-analysis. Nine studies were available for road traffic, with only two for railway noise and two for aircraft noise. The authors found minor effects of railway and road noise on mortality.

2.23 The risks of road traffic noise on ischemic heart disease, heart failure and stroke are discussed. Effects on arrythmia and AF are presented, with the authors citing the results from the Peters et al study on Nordic populations, for road noise.

2.24 The authors concluded that there was an association between road noise and several cardiovascular risks. They combined the IHD, stroke, hypertension, arrhythmia and heart failure results to produce a global cardiovascular risk increase of 3.2% (95% CI: 1.1–5.2%) per 10 dB L_{den} increase in road traffic noise. They explain that for aircraft noise and railway noise this is less noticeable, possibly because road noise is masking these noise sources to some extent. It is suggested that intervention studies are needed to demonstrate risk reduction following the implementation of noise mitigation measures.

2.25 The review discusses the impacts of transportation noise on oxidative stress and endothelial function. In terms of aircraft noise, the results from Schmidt et al (2013) are highlighted, which found that endothelial flow mediated dilation of the brachial artery decreased with the increasing number of aircraft noise events presented. A priming effect was also observed, where participants who were exposed to the 30 aircraft noise events condition first, exhibited a stronger reduction of flow mediated dilation response when then exposed to the 60 events condition. There was also an increase in plasma adrenaline levels with the increasing number of aircraft noise events. Effects on oxidative stress have also been found, and the mechanisms by which this occurs are discussed in detail.

2.26 The authors discuss the prevention and mitigation strategies for reducing road, rail and aircraft noise. For aircraft noise, they suggest that implementing GPS-guided routes can help avoid densely populated areas. Night-time bans could help with the effects of sleep disturbance. Continuous descent approaches with steeper descents, and lower throttle settings can minimize noise during landings. The development and use of quieter aircraft technology can have a long-term impact on reducing noise pollution from aviation.

2.27 There is also need for consideration of co-exposures such as air pollution in future research, given animal research has indicated that there is an independent effect of both noise and air pollution on oxidative stress and endothelial function.

2.28 **Gong et al** published findings from the RISTANCO epidemiological study, on the impact of short-term aircraft noise on cardiovascular risk in the area around

Heathrow. The "Reduced Noise Impacts of Short-Term Aircraft Noise," (RISTANCO) is a National Institute of Health Research (NIHR) funded study investigating the short-term impacts of aircraft noise on cardiovascular events, with a focus on whether day-to-day changes in aircraft noise are associated with increased risk.

2.29 The rationale for this study was that there are several studies investigating long-term cardiovascular impacts of aviation noise, but a lack of studies on the short-term effects of aircraft noise on the cardiovascular system. The study also examined respite periods in terms of their health benefits to residents. The aims of the study were to ascertain whether there was a significant short-term impact of aircraft noise on morbidity and mortality, exploration of interactions of age, gender, deprivation and ethnicity, the difference in risk between areas exposed to changing patterns of noise exposure versus consistent noise exposure, and the impact of using different noise metrics on any outcomes.

2.30 Aircraft noise (L_{Aeq}) was modelled between 2014-2018 at different times of day, for bands of time, and number of aircraft events above defined thresholds (2018 only). The time bands were night-time, morning shoulder, morning, afternoon, evening, late evening, night-time shoulder, which correspond to aircraft operation periods. The measured health outcomes were NHS Digital hospital admission records and mortality records from the Office for National Statistics for 2014–18 for cardiovascular outcomes, plus individual-level factors available from healthcare records (e.g. age and sex). In addition, confounding variable data was obtained for road noise, rail noise, air pollution, deprivation, avoidable death rate, fuel poverty and ethnicity.

2.31 The authors described the patterns of noise exposure as the highest levels of noise being found in the morning shoulder period (06.00–07.00 hours; mean: 50.92 dB; 90th percentile: 52.08 dB) and daytime (07.00–15.00 hours) (mean: 49.87; 90th percentile: 51.50 dB). On average, the night shoulder and night quota periods (23.30–04.30 hours) were the quietest.

2.32 Postcodes within the study area during daytime experienced an average of eight noisy flight events (> 65 dB), with 10% of postcodes experiencing ten events. The morning shoulder period had the highest levels of aircraft noise and had the third highest number of noisy events (flights) > 60 dB per day, with three events across postcodes on average. During the night quota period (04.30–06.00 hours), the average number of noisy flight events (> 60 dB) per postcode was one.

2.33 The authors found there were inequalities with the aircraft noise exposure around Heathrow, based on levels of deprivation. The authors also published a paper discussing this finding within the wider study (**Gong et al 2025**). Three different measures of deprivation were used to examine any link between aircraft noise exposure. The Carstairs index, yearly avoidable mortality rates, and yearly fuel poverty rates were analysed with daily aircraft noise metrics L_{day}, L_{eve}, L_{night}, and L_{Aeq24}. The authors found positive associations between avoidable death rates and all noise metrics but the associations between noise and the Carstairs index or fuel poverty were not clear. Areas with higher ethnic diversity experienced higher aircraft noise levels.

2.34 Within the main study, to examine the short-term impact of aircraft noise, all recorded hospitalisations (n = 442,442) and deaths (n = 49,443) in 2014–2018 due to CVD were included in the analysis. The authors found a statistically significant increase in risk for cardiovascular disease hospital admissions for a 5-dB increment in noise during L_{eve} [L_{eve} OR 1.005, 95% confidence interval (CI) 1.000 to 1.010], particularly from 22.00 to 23.00 hours [OR 1.006, 95% CI 1.002 to 1.010], but they did not find statistically significant associations for other periods, or for mortality.

2.35 To examine the variation in noise exposure levels due to respite, the coefficients of variation (CoV) of daily aircraft noise levels were calculated by postcode for the entire dataset (all four seasons) or by season (summer, summer transition, winter and winter transition). It was found that night-time (24.00–04.30 hours) had the highest mean CoV (67.33–74.16), followed by 04.30–06.00 and 23.00–24.00 hours. It is explained that the variation in aircraft noise was lower during the daytime.

2.36 The authors stratified the cardiovascular disease data by CoV, which indicated a statistically significant adverse association between evening noise levels (19.00–22.00 hours, 22.00–23.00 hours and 23.00–24.00 hours) and hospital admission for cardiovascular disease in low (below mean) CoV postcodes but not in high CoV postcodes. Further analysis revealed that no inference could be drawn between lack of respite periods and risk of hospitalisation.

2.37 The authors concluded that the findings suggested an association between short-term exposure to noise during evening and night-time hours, and an elevated risk of hospital admissions (but not deaths) for cardiovascular disease. They suggest that further study into short-term aircraft noise exposure and cardiovascular disease is required, and there is a need to further explore the variability of noise exposure and cardiovascular disease. The examination of effect modifiers such as noise insulation could be an area for further study, and the authors also suggest further research is needed into aircraft noise and deprivation.

2.38 **Topriceanu et al** published the findings from their MRI study examining aircraft noise exposure, heart structure and function. It is explained that previous studies have indicated that aircraft noise (especially during the night) can lead to diastolic dysfunction, higher systolic blood pressure and endothelial dysfunction in patients with or at risk of coronary artery disease, increased vascular stiffness, more pronounced stress hormone release, and greater oxidative stress and inflammation. The exact mechanisms for the relationship between aircraft noise and these outcomes are not fully understood.

2.39 In this study, aircraft noise data (L_{night} and L_{den}) from 2011 were analysed against health data from the UK Biobank participants living near Heathrow, Gatwick, Manchester and Birmingham airports, and who had cardiovascular magnetic resonance (CMR) imaging starting from 2014. Over 3,600 participants were included, with 3% experiencing ≥45 dB L_{night}, and 8% experiencing ≥50 dB L_{den}.

2.40 The results indicated that for those people who did not self-report any hearing difficulties, participants exposed to higher aircraft noise (≥45 dB L_{night}) had larger left ventricle (LV) volumes (all $P \leq 0.006$), including greater left ventricle end-diastolic volume, greater left ventricle end systolic volume, and greater myocardial volume, after adjusting for demographic, socioeconomic, cohort-related, lifestyle, and environmental confounders (including road and rail noise, and concentrations of NO_2 and $PM_{2.5}$ in the air). The authors also explained that in addition, they also had concentrically thicker hearts, and worse left ventricle dynamics, as suggested by the lower absolute LV global strain indices.

2.41 The authors related this to the associated risk of major adverse cardiac events (MACE) and reported that there was a 27% increased chance of MACE with the given LV strain values. They stated that in a hypothetical individual experiencing the typical CMR abnormalities associated with a higher L_{night} exposure may have a four times higher risk of MACE. Findings were clearest for L_{night} but were broadly similar in analyses using L_{den}. Body mass index and hypertension were mediators for between 10-50% of the reported associations. Those participants who did not move house and were exposed to the higher levels of aircraft noise exhibited the worst cardiac values.

Chapter 3

Aircraft Noise and Other findings

3.1 This chapter outlines the findings from research on aircraft noise and other health effects during the six months between September 2024 and March 2025.

Sleep disturbance

3.2 **Gong et al** published findings from the UK Biobank cohort study on the associations between aircraft noise, sleep and the sleep-wake cycle using actimetry data. The aim of the study was to provide large-scale objective data using actimetry (wrist-worn devices that measure movement as a proxy for sleep). The objective of the study was to investigate the association between night-time aircraft noise exposure and actigraphy-generated sleep disturbance outcomes in approximately 100,000 participants living around four major UK airports.

3.3 A description of the data collection is provided by the authors. UK Biobank conducted baseline and follow-up assessment visits. The baseline assessment (instance 0; 2006–2010) included data collected at the time of recruitment, such as information on demographics, lifestyle factors, medical history, physical measurements, and biological samples. The first follow-up visit (instance 1) was conducted in the period 2012–2013. During that period, a total of 103,514 participants were invited to participate, and of those, 20,345 participants attended further assessments.

3.4 The actimetry outputs examined included average acceleration during the least active 8-hour period, indicating the overall activity during the rest period of the wearer. The 8-hour period (average from 23:06 to 07:06 in this study) was chosen by the authors due to the alignment of the L_{night} metric (23:00 to 07:00). The overall average proportion of time spent on sleep or in bed (defined as non-waking time) was also measured, along with relative amplitude (RA) (the contrast in activity levels between the most active 10 hours and the least active 5 hours within a 24-hour period), intradaily variability (IV) (the fragmentation of the 24-hour rest–activity rhythm), and interdaily stability (IS) (the stability of the rest–activity rhythm). Self-reported measures were also taken on insomnia, dozing and sleep duration.

3.5 The results indicated that individuals exposed to L_{night} ≥55 dB exhibited 0:12 mg (95% CI: 0.013, 0.23) higher average acceleration during the least active 8-hour period than those exposed to <45 dB. The authors observed a similar pattern of association when looking at ≥45 dB to <50 dB or ≥50 dB to <55 dB. The authors suggested that the risks increased with increasing noise level. These results are shown in Figure 2.

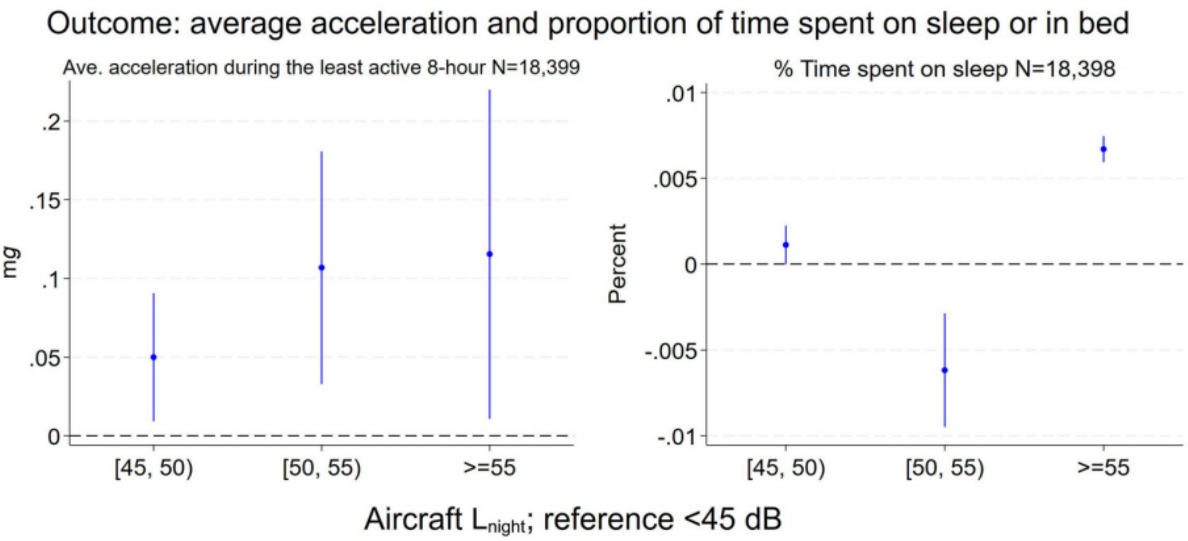

Figure 2: Cross-sectional association between nighttime aircraft noise and actimetry data on average acceleration, measured in milligravitational units (mg) during the least active 8 h, and percentage of time spent on sleep or in bed using UK Biobank cohort (n= 18,398–18,399).

3.6 The results also indicated that individuals exposed to noise levels ≥55 dB L_{night} spent ~0:7% (95% CI: 0.6%, 0.7%) more time on average on sleep or in bed, equivalent to approximately 10 minutes per day in comparison with those exposed to <45 dB. In the group exposed to noise levels ≥50 dB to <55 dB, there was an approximate 0.6% lower (approximately 8 minutes) in average sleep or bedtime (95% CI:−0:9%, −0:3%).

3.7 For the sleep-wake measures, the authors reported that there was a gradient association observed for each of the three outcomes (RA, IV and IS), shown in Figure 3. A higher RA value indicates greater activity during the day and reduced activity during sleep. A higher IV suggests a fragmented circadian rhythm, and a higher IS value indicates strong association with light and other external cues that regulate the circadian clock.

3.8 The self-reported results suggested a 13% higher chance of sleeplessness sometimes or usually in participants exposed to aircraft noise levels of 55 dB L_{night} or higher compared to those people exposed to noise levels below 45 dB. Daytime dozing reported by approximately 3% of the study population suggested that those people exposed to noise levels of 55 dB L_{night} or higher had an approximately 52% higher likelihood of daytime napping. No association was found between nighttime noise and self-reported sleep duration.

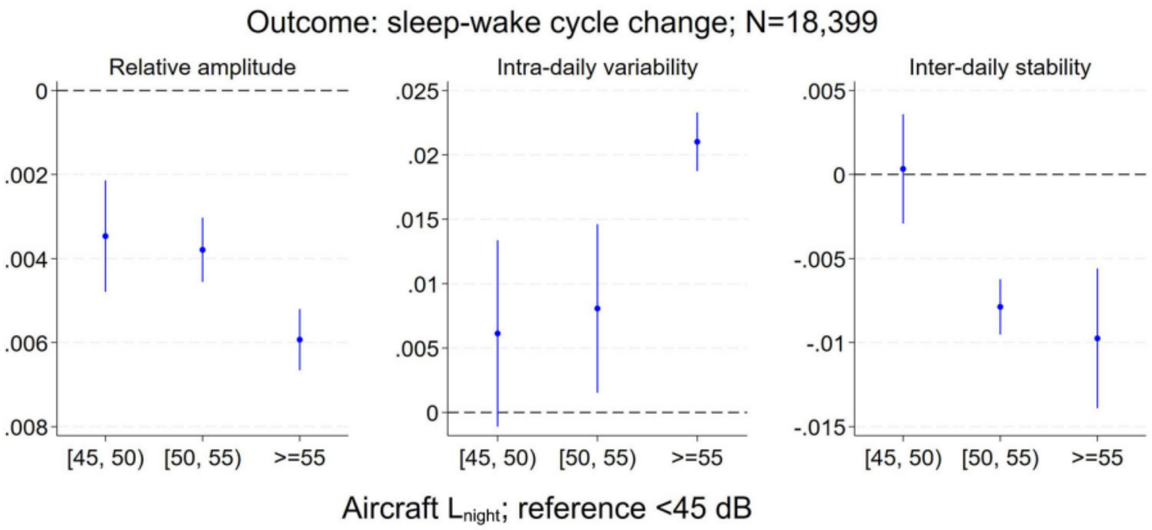

Figure 3: Cross-sectional association between nighttime aircraft noise and sleep–wake cycle using UK Biobank cohort (n = 18,399).

3.9 The sensitivity analyses revealed that elderly individuals exposed to ≥55 dB L_{night} had a 5.4% higher (approximately 1 hour and 8 minutes within a 24-hour period on average) actigraphy-measured sleep duration. The authors also reported potential greater effects in participants with diabetes, dementia, and sleep disorders, although they cautioned that this finding was based on smaller numbers.

3.10 They concluded that the study was one of the first to provide large scale objective sleep data and nighttime aircraft noise using actimetry around four major airports in the UK, and the results highlight the need for consideration of noise mitigation strategies for nighttime aircraft noise.

Projected health impacts from transportation noise in 2030

3.11 At the end of 2024, the European Environment Agency (EEA), as part of a grant with the European Topic Centre on Human Health and the Environment published their methodology for calculating projected health impacts from transportation noise, and examined two scenarios for road, railway and aircraft noise (**Blanes et al**).

3.12 The aim of the report was to assess the feasibility of reducing the number of people chronically disturbed by transport noise by 30% by 2030, as part of the Zero Pollution Action Plan. The report does not contain the projected numbers of people affected; it is centred on the methodology proposed.

3.13 The methodology explored the latest noise data and examined the potential noise exposure levels across the EU, Iceland, Norway and Switzerland. Two scenarios were developed for road, rail, and air traffic noise inside and outside urban areas: a Conservative Estimate (CE), which assume minimum implementation of existing and forthcoming regulations, and a Best

Implementation Estimate (BEI), which considers optimal implementation of noise reduction measures.

3.14 For road traffic noise inside agglomerations factors considered included population change, transport activity, regulation on vehicle sound levels, electric vehicles, low noise asphalt, noise barriers, and speed limits. For road traffic noise outside agglomerations similar factors but with different implementation levels were considered. For rail noise inside agglomerations aspects such as included population change, transport activity, new urban rail infrastructure, silent brake policy, and rail maintenance were considered . Outside these areas, high-speed lines, electrification and noise barriers were also factored. For aircraft noise, factors included population change, traffic growth, quieter aircraft, improved landing/take-off procedures, and night curfews.

3.15 The report proposed calculation of the number of highly annoyed and highly sleep-disturbed people due to aircraft noise exposure, using the exposure-response functions from WHO guidelines. The assessment considered noise levels above and below the Environmental Noise Directive (END) thresholds, aligned with WHO noise guidelines. The projections rely on various assumptions and approximations, and the potential for reduction varies between countries.

3.16 For the two aircraft noise scenarios CS and BEI, (inside and outside agglomerations) the factors for consideration were:

- Population Change: Based on LUISA model projections for 2020, 2025, and 2030.
- Traffic Forecast Activity Change: Eurocontrol's base scenario predicts a 3.6% annual growth in air traffic from 2022 to 2030, resulting in a 0.14 dB increase per year.
- Quieter Aircraft: Assumes a 0.1 dB reduction per annum due to the introduction of quieter aircraft models.
- Improved Landing/Take-off Procedures: Noise reduction of 2 dB for take-off procedures across all airports.
- Night Curfews: For the best scenario, a 2 dB reduction in L_{night} due to night curfews, with a 0.5 dB reduction in L_{den}.

3.17 Aircraft noise exposure may be associated with health outcomes such as chronic sleep disturbances, stress activation of the autonomous nervous system and hypothalamus-pituitary-adrenal (HPA) axis, leading to increased risk of cardiovascular disease, metabolic issues (diabetes), and mental health issues. The health risk calculations for the projections involved disaggregation of the exposure distribution of the target population, application of the WHO exposure-response functions, and summation to obtain the number of highly annoyed and highly sleep disturbed people. In this report the number of highly annoyed and highly sleep disturbed is calculated for the EU as a whole and for each EU country, stratified by inside and outside agglomeration. This calculation is proposed to be calculated for each scenario 2017, 2022, and 2030. For the calculation of %HA the exposure distribution of L_{den} is used, and for the calculation of %HSD the exposure distribution of L_{night} is used.

3.18 The authors explain that the projections proposed in this methodology are informed by existing noise regulations, the implementation of measures outlined in action plans reported under the END, recent research on noise management, and forecasts related to population and transportation.

Global Burden of Disease

3.19 **Clark et al** published their review of global burden of disease from environmental factors, and this included environmental noise pollution. The review explains that estimating disease burden from environmental factors can help to prioritise public health actions. The World Health Organization (WHO) began these estimations in 2000, forming the basis for the Global Burden of Disease (GBD) study.

3.20 In 2001, environmental and occupational risk factors were stated as being responsible for 18.9% of global deaths and 14.4% of all disability-adjusted life years (DALYs), led by ambient $PM_{2.5}$ air pollution (4.2% DALYs, 4.7 million deaths) and household air pollution from solid fuels (3.9% DALYs, 3.1 million deaths).

3.21 The authors explain the impact of climate change, increasing environmental hazards such as disease burdens from heat, air pollution, vector-borne diseases, storms, and flooding. The WHO projects climate change could increase global deaths by 250,000 annually between 2030 and 2050. Other environmental risk factors include indoor air pollution, which is a significant contributor to disease burden, especially in certain countries; chemical exposures such as lead, mercury, pesticides, and other hazardous substances. Environmental noise such as that from road, rail and aircraft is also a risk factor, due to the links between cardiovascular diseases, sleep disturbances, and cognitive impairment. Exposures throughout the day and night are associated with cardiometabolic disease incidence e.g., ischemic heart disease, heart failure, stroke, and type 2 diabetes, due to the activation of the stress response which may be mediated by sleep.

3.22 The review refers to the numbers in the WHO 2011 Burden of Disease from Environmental Noise report, which stated that in Western European countries at least one million DALYs were lost annually from traffic-related noise exposures, with the main part of the burden arising from sleep disturbance and annoyance. The authors explain that currently, estimations are mostly limited to areas with detailed noise exposure data (mostly in Europe), and that scaling up to a global assessment is challenging due to a lack of data in many regions. Some studies in low- and middle-income countries show higher noise levels than in European cities, indicating potentially significant but currently unknown health burdens. It is explained that researchers are working to identify and use data to model global road traffic noise exposures for burden of disease assessments. As more epidemiological evidence becomes available, future assessments may include a broader range of health outcomes, such as childhood behavioural problems and adult mental health issues.

3.23 The report summarises the evidence for burden of disease estimates for other environmental factors, and comparisons were drawn between climate change, chemical exposure, indoor air pollution and environmental noise. Ambient air pollution ($PM_{2.5}$) was the largest contributor to environmental disease burden, particularly impacting mortality. Occupational exposures and indoor air pollution were also significant contributors in Europe (Figure 4). It was highlighted that climate change may exacerbate exposures like ambient $PM_{2.5}$, increasing associated health burdens over time. The authors concluded that environmental risk factors substantially contribute to the global burden of disease, accounting for 15-25% of it, but there is a lack of global data for many environmental risk factors, and such gaps should be filled to understand and mitigate their impacts on people.

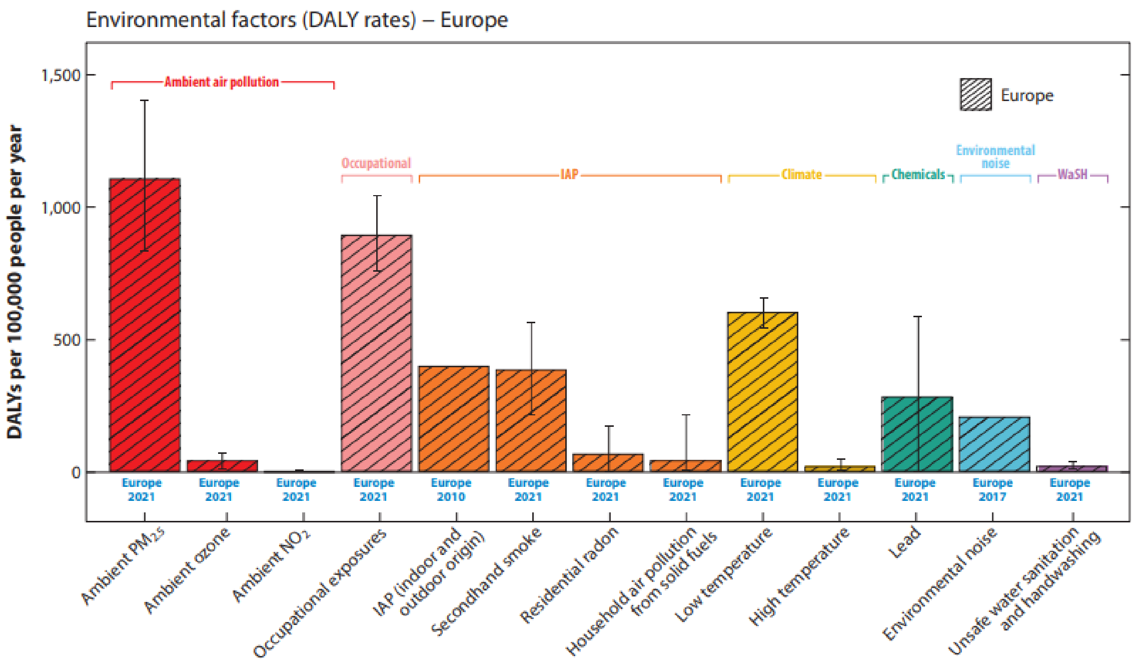

Figure 4: Annual DALYs lost per 100,000 people (all ages) in Europe attributable to environmental risk factors covered within the review by Clark et al.

Noise impacts and children

3.24 **Van Kamp** authored a review of noise and heath in children. The context for this review is that young children and adolescents are particularly vulnerable to noise due to their continuous physical and cognitive development. Early exposures may have implications later in life. It is explained that certain life phases are thought to be more susceptible to environmental health effects, and health effects during these periods can also be co-affected by other factors. Although the review covers the effects of road noise in depth, only the findings relating to aircraft noise are discussed in this report.

3.25 The WHO environmental noise guidelines (2018) highlighted critical health outcomes for children, such as sleep disturbance and cognitive impairment from reviews of the evidence up to 2014. Evidence for aircraft noise was inconsistent and the quality was rated as very low. There was moderate evidence for an association between aircraft noise and reading and oral comprehension, and other measures related to cognition such as performance, and long-term memory. No effect of aircraft noise was found on children's attention and working memory.

3.26 Since 2014 new studies have enhanced understanding of the link between environmental noise and health in children, including effects on birth outcomes, annoyance, sleep, cardiovascular health, neuroendocrine effects, cognition, and mental health. For aircraft noise, annoyance and cognition effects were referred to in the paper. The author explains that studies on annoyance in children are rare. The NORAH study (2017) investigated annoyance responses of school children 7-10 years of age. The results suggested that annoyance was strongly associated with aircraft and road traffic noise exposure (L_{Aeq}) at school.

3.27 In terms of cognition, the author referred to the review by Thompson et al in 2022, who published a meta-analysis on the impact of environmental noise and cognition. This review suggested moderate quality evidence for an association between aircraft noise and reading and language acquisition in children, and moderate quality evidence against an association between aircraft noise and executive functioning in children. Sebai's 2015 study is also referred to, which found that exposure to chronic aircraft noise may have a lasting impact on children's reading comprehension.

3.28 The mechanisms by which environmental noise may affect children are discussed. The Stress-Based Framework whereby noise exposure is associated with stress responses, which can lead to health effects is a common explanation for the impacts of noise. It is suggested that children have fewer coping skills and may react to noise in a physical way. Learned Helplessness is suggested as another possible route, whereby continuous exposure to noise can lead to learned helplessness, affecting motivation and cognitive functioning.

3.29 In a broader environmental context, the author highlights the importance of studying combined exposures in future. She suggests these studies should focus on early life and life course exposures, and examine the combined effects of noise, air pollution, and access to green spaces. Furthermore, she proposes addressing the contextual and root causes of social inequalities is important for furthering health and education outcomes.

3.30 It is concluded that preventative action is important for the protection of children against the harmful effects of transport noise, and more tailored noise regulations specifically aimed at children and adolescents can benefit society by enhancing health and education outcomes.

Chapter 4

Summary

4.1 This update report has summarised the main findings in the field of aircraft noise and health effects research over the six-month period between September 2024 and March 2025. There have been several studies on the cardiovascular impacts of aircraft noise, with the UK RISTANCO study examining short-term impacts of aircraft noise on the cardiovascular system. The use of MRI imaging in another study to assess the effects of noise on the heart structure has provided novel findings.

4.2 Other findings have included the widespread use of actimetry data to assess the effects of aircraft noise on sleep disturbance in the UK, a proposed methodology to assess projected numbers of people exposed to impacts from noise in 2030, an examination of environmental factors in the global burden of disease, and a discussion of the health impacts of noise on children.

4.3 The aim of this report was to provide an overview of the recently published findings on aircraft noise and health effects, and the next report is due in September 2025, and will include new findings presented at the Internoise and Euronoise congresses.

Chapter 5

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