Environmental Research Consultancy Department

Civil Aviation Authority

Aircraft Noise and Health Effects – a six monthly update

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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 from September 2020 – March 2021. There were no relevant acoustics Congresses held during this period, so the report will provide an overview of the recently published papers in the area of noise and health, and includes a summary of the Neighbourhood Environmental Survey, conducted by the Federal Aviation Administration (FAA).

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 conference, nor takes any view on their applicability to UK policy making. The authors would like to thank Bernard Berry (Bel acoustics) for his valued contribution to the source material.

Chapter 2

Research findings

2.1 The following research findings were published during the past six months since September 2021. They are presented in this chapter according to subject area.

Aircraft Noise and Mental Health

2.2 Li et al. published a paper examining aircraft noise control policy and mental health. The study focused on older adults and included data on the impact of environmental noise policy on depressive symptoms from a national experiment provided by the New Deal aircraft noise control policy, which was introduced in Schiphol Amsterdam in 2008.

2.3 The study focused on adults aged between 57-102 years old. The rationale for examining this age range was that noise studies are often conducted on younger adults or the general population. Older people may be at increased risk due to environmental noise due to their lower residential mobility, increased time spent at home and higher sensitivity to environmental influences on sleep disturbance and annoyance.

2.4 In response to the EU Noise Directive, which requires countries to produce noise maps and action plans every 5 years, there have been new noise control policies introduced across European countries. In Schiphol, Amsterdam, a noise control policy was approved in 2008, called the ‘Nuisance Limit and Schiphol Development Deal’. This resulted in changes to flight routes and night procedures. The Schiphol Deal aimed to reduce by 5% the number of individuals experiencing disturbance inside the 48 dBA Day-evening-night level (L_{den}) noise contour.

2.5 Over 1,700 participants were included in the study in each of the three waves (2005/2006, 2008/2009 and 2011/2012) of the Longitudinal Aging Study Amsterdam (LASA). Depressive symptoms were measured with the Centre for Epidemiologic Studies—Depression (CES-D) scale, a validated 20-item measure to detect both clinical and non-clinical depressive symptoms. The 0-60-point scale measures features of depression, for example: mood, feeling worthlessness, helplessness and hopelessness. These symptoms were measured before and after the new noise policy was implemented, in people living less than 15 km from the airport, and those living further away (>15 km).

2.6 The address-level aircraft noise data for 2005, 2008 and 2012 were first aggregated at six-digit postcode level and then linked to LASA participants in the 2005/2006, 2008/2009 and 2011/2012 waves. Information on participants’ age, marital status, employment, retirement, household income and physical functioning were also included.

2.7 A difference-in-differences (DiD) approach was used by the researchers to assess the impact of the Schiphol New Deal policy. An estimation of the impact of the policy on aircraft noise levels was made, by comparing changes in noise levels before and after the implementation of the policy for individuals in households located close to the airport (treatment group), and compared these to changes in noise levels for individuals living far from the airport (control group).Treatment was defined as living closer than 15 km from Schiphol Airport.

2.8 The results indicated that participants living closer to the airport were exposed to higher levels of aircraft noise and reported higher average levels of depressive symptoms relative to those living further away. Noise levels remained constant in control areas (far from the airport), while they decreased in 2009 before increasing again in 2012 in treatment areas (close to the airport). Levels of depressive symptoms remained constant in treated areas, while control areas experienced a reduction over the study period, leading to a widening gap between the two groups.

2.9 The authors concluded that the study found no evidence that a policy that aimed to reduce aircraft noise around Schiphol airport resulted in reduced noise levels. There was also no evidence that the policy reduced depressive symptoms in older people living close to the airport.

2.10 It was suggested that existing approches for reducing aircraft noise may not be effective at making further reductions over what has already been achieved, and therefore have a limited potential to impact the mental well-being of older people.

2.11 The authors explain that these findings suggest that existing noise control policies may need to be revised or expanded to generate significant changes. Further research should examine whether more comprehensive policies in other airports may have had larger effects on noise and the mental wellbeing of older people.

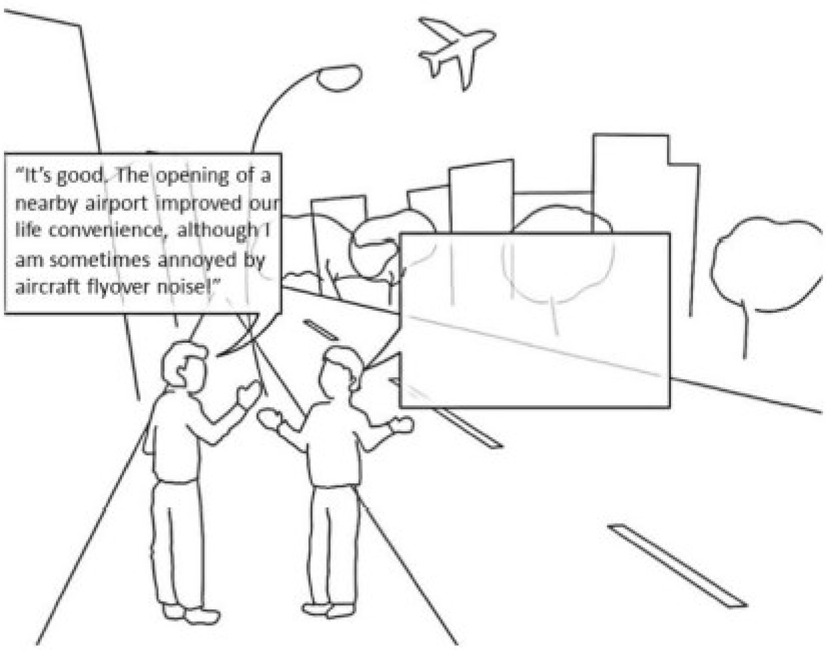
Attitudes to Aircraft Noise

2.12 Nguyen et al published a paper on the assessment of residents' attitudes to aircraft noise around Hanoi Noi Bai International Airport, in Vietnam. A new terminal building at the Hanoi Noi Bai International Airport (NBIA) was completed and opened in December 2014 with plans to increase the airport capacity to cope with the growing demand for aircraft movements. This study was conducted after the opening of a new terminal building in September 2015, with the aim of investigating people's attitudes toward the airport, aircraft noise, their living environment, and their awareness of environmental protection of their communities, as well as to clarify a variety of public opinions related to the Airport.

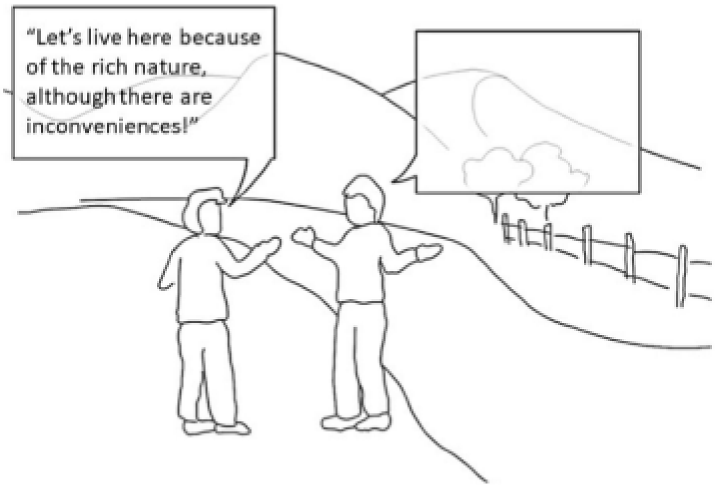
2.13 In this study, in addition to a questionnaire, the researchers used the Rosenzweig Picture-Frustration test (P-F test), which is a tool to explore an individual's real feelings toward frustrating situations using cartoons and uses open-ended questions and allows participants to imagine their circumstances.

2.14 The test involves a participant responding verbally to a semi-ambiguous picture scenario. The test form consists of 24 comic strip pictures that portray a situation that might induce frustration to assess how the participant responds to frustration and frustrating situations. The test assumes that the way that the participant responds to each frustrating situation depicts how they behave in the face of frustration. The aim of the test is to measure the type of reaction, not the type of personality.

2.15 In the P-F test, the reactions to the pictures must be written down. Therefore, it is expected to reveal respondents' real thought content more directly than if respondents must rate their response on a verbal or numeric scale used in the questionnaire surveys. In this study, a set of cartoons for the P-F test were developed as a new means to examine the environmental attitudes of residents living near an airport, concerning their desires and preferences of life convenience and environmental protection. The aim was then to use the findings to assist with the employment of effective noise-abatement programs that not only focus on decreasing noise emission, but also seek solutions to enhance the co-existence of an airport and local communities. The cartoons 1-5 below are examples of those included in the P-F test in this study.



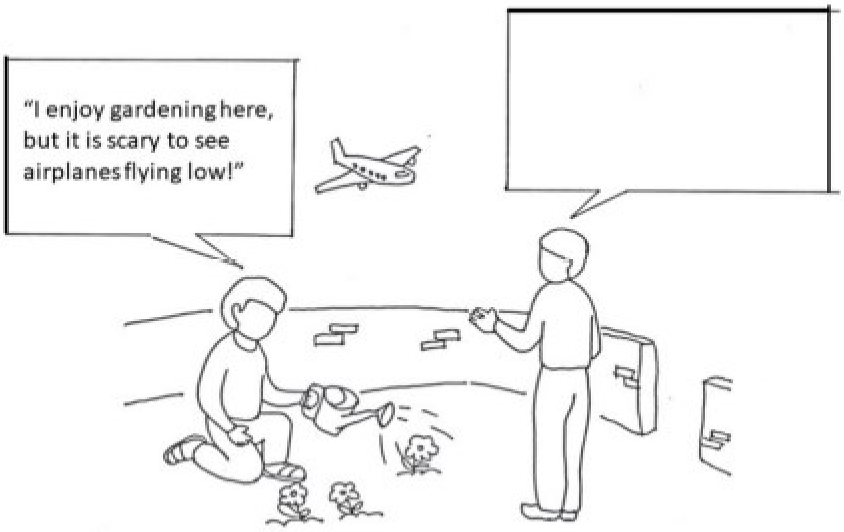
Cartoon 1



Cartoon 2

Cartoon 3

Cartoon 4



Cartoon 5

Figure 1: Examples of cartoons included in the P-F test to assess attitudes to aircraft noise and the environment.

2.16 The five cartoons describe the following frustrating situations:

(a) Cartoon 1: Aircraft noise vs. life convenience.

(b) Cartoon 2: Natural environment vs. life convenience.

(c) Cartoon 3: Environmental preservation vs. life convenience.

(d) Cartoon 4: Sleep disturbance vs. life convenience.

(e) Cartoon 5: Fear of aircraft crash vs. joy of gardening.

2.17 Following the P-F Test, participants then answered a questionnaire, which was used to obtain demographic data and responses to seven questions relating to:

1) Evaluation of the living area including queries on the natural environment, scenery, view, and convenient access to social facilities.
2) Condition when being annoyed by aircraft noise.
3) Specific time most annoyed by aircraft noise.
4) Degrees of annoyance
5) Actions taken when being annoyed by aircraft noise
6) The appropriate measures to solve aircraft noise problems
7) Attitudes toward the airport and aircraft noise (this question comprised 21 agree/disagree sub-questions)

2.18 The report explains the detailed results for each question and cartoon presentation; the sample size of the study was 321. In summary, the results indicated a significant variation in attitudes toward the airport and natural environment among residents in different areas. Residents in urban areas preferred a natural environment more than those living in rural and mixed sites, who desired harmony between nature and life convenience. Residents in rural sites raised more complaints about aircraft noise effects on sleep than those in the other sites. Non-acoustic factors such as occupation and gardening activities did not affect residents' attitudes toward the airport. The attitudes of the participants varied depending on the noise exposure levels. It was suggested that using multiple questioning methods is necessary to certify the true opinions and aspirations of people living in the project area and ensure sustainable development.

2.19 Regarding "sleep disturbance," L_{night} values between 55 and 60 dBA result in up to about 90% disturbance with the P-F test. For L_{den} values at about 65 dB, about 80% of the participants are annoyed according to the results of the questionnaire.

2.20 Figure 2 illustrates the response-relationships from this study compared to those found by the World Health Organisation (published in the Environmental Noise Guidelines for the European Region).

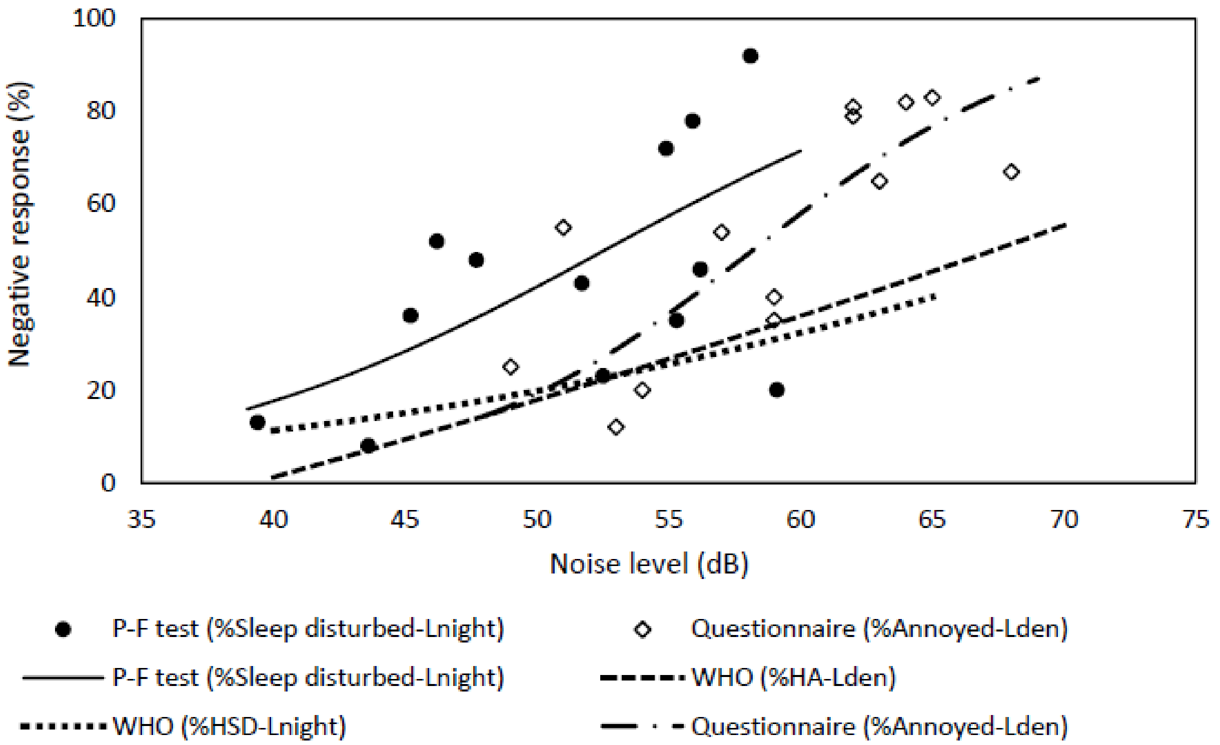


Figure 2: Comparison of exposure-response relationships obtained from the P-F test and questionnaire. % Sleep disturbed (L_{night}) relationship obtained from the P-F test, and % Annoyed L_{den} relationship obtained from the questionnaire.

2.21 In this study, the percentage of participants who selected either of the first two categories of the four-point scale, or top 50% on the evaluation scale were classed as Annoyed.

2.22 Regarding "sleep disturbance," answers for Cartoon 4 in the P-F test were classified to calculate % Sleep disturbed. The relationships in the WHO's guidelines are based on data of studies that measured the effect of aircraft noise on self-reported annoyance and sleep outcome. The percentage of highly annoyed persons (%HA) and highly sleep disturbed (% HSD) was obtained from the top 27 and 28% on the evaluation scale. Since the higher value of the cut-off point induces a higher prevalence of annoyance and disturbance, this study's dose-response relationships are steeper than those established in WHO's Guidelines.

2.23 A more negative response was obtained from the P-F test than from the questionnaire. With the same cut-off point, the level of sleep disturbance obtained by the P-F test is higher than that obtained in the questionnaire.

Traffic noise and mortality

2.24 Cai et al published a paper on long-term traffic noise exposure and mortality. This was an updated meta-analysis of the evidence published between 2000 and 2010, and included road, railway and aircraft noise in relation to non-accidental and cardiovascular mortality.

2.25 Thirteen studies were included in the analysis, following a literature review and inclusion criteria selection. Risk estimates from each study were converted into risk increase with every additional 10 dB L_{den} of noise dose for each traffic source.

2.26 The results indicated that for road traffic, the pooled relative risk (RR) per 10 dB higher L_{den} for mortality from non-accidental causes was 1.01 (95% CI: 0.98, 1.05) (5 studies, I2 = 78%), CVD was 1.01 (95% CI: 0.98, 1.05) (5 studies, I2 = 41%), ischemic heart disease (IHD) was 1.03 (95% CI: 0.99, 1.08) (7 studies, I2 = 46%), and stroke was 1.05 (95% CI: 0.97, 1.14) (5 studies, I2 = 62%).

2.27 The authors concluded that the overall quality of evidence for most meta-analyses was rated as very low to low, except for cardiovascular disease or Ischaemic Heart Disease mortality, for which the quality of evidence was rated as moderate. A possible threshold of 53 dB was visually suggested for cardiovascular disease related mortality from road traffic noise in the trend analysis. For aircraft noise, pooled estimates were based on fewer studies and varied by mortality outcomes.

2.28 The evidence of long-term exposure to traffic noise on mortality remains weak except the association between road traffic noise and IHD mortality. The authors suggested that there is a need for high-quality longitudinal studies in order to better understand and characterise the mortality effects of traffic noise.

Night-time aircraft noise and mortality

2.29 Saucy et al published a paper on the link between nocturnal aircraft noise and the possible link with acute mortality. This was a case-crossover study on nearly 25,000 people who had died, in the vicinity of Zurich airport between 2000 and 2015.

2.30 The rationale for this study was that although the effects of long-term exposure to nocturnal aircraft noise is well studied, there is a need to further understand whether noise exposure also acts as a trigger for acute cardiovascular events and how the timing of noise exposure controls this response. The aim was to investigate if and how night-time aircraft noise can trigger mortality for cardiovascular diseases.

2.31 The study involved conducting separate analyses for night-time and daytime deaths, and also tested three different noise exposure metrics to capture the characteristics and evolution of noise over time for various exposure windows.

2.32 A case-crossover design methodology was used, which adjusts for any individual confounders that do not vary over a short period of time, such as age, smoking, or socio-economic status. The authors explain that this approach is particularly well suited to investigate acute risk effects and has been applied to air pollution studies. The study investigated deaths occurring during the day (07:00–23:00), and deaths occurring during the night (23:00–07:00). For the night-time deaths, a 2-hour exposure window preceding death was considered. For deaths occurring during the daytime, the effect of five different exposure windows within the night preceding the day of event were categorised:

i) overall night preceding the day of death (23:00–07:00)

ii) late evening (19:00–23:00)

iii) reduced air traffic reserved for delayed flights (23:00–23:30)

iv) core night (23:30–06:00)

v) early morning (06:00–07:00).

2.33 The study population was adults over 30-years old, with the cause of death being cited as cardiovascular related, living near Zurich Airport. This was ascertained using the envelope of the Zurich Aircraft Noise Index (ZFI) calculation parameters from 2000 to 2016 for highly annoyed and highly sleep disturbed people. Ischaemic Heart Disease (IHD), Myocardial Infarction (MI), stroke, haemorrhagic stroke, ischaemic stroke, heart failure, blood pressure related death, and arrhythmias were all included as relevant causes of death.

2.34 Three noise metrics were investigated:

(i) average A-weighted equivalent continuous sound pressure level (L_{Aeq})

(ii) maximum sound pressure level (L_{Amax})

(iii) number of events above threshold 55 dB (Number Above Threshold 55) for the pre-defined time windows.

2.35 The association between average aircraft noise and cardiovascular mortality was estimated using conditional logistic regression. 7,641 deaths occurred during the night and 17,245 during the day. The mean L_{Aeq} ranged from 17.6 to 45.2 dB for the different exposure time windows. On average, all three-noise metrics were highest in the evening time window (19:00–23:00) and lowest in the core night (23:30–06:00).

2.36 The results indicated that there was an association between 2-hour aircraft noise exposure preceding the time of a cardiovascular death during the night (Figure 2). This was particularly the case for IHD, MI, heart failure, and arrhythmias. The odds of night-time cardiovascular mortality (all causes) was significantly increased for 2-hour L_{Aeq} values above 40 dB. The lower number of cases for some diagnoses (e.g. haemorrhagic and ischaemic strokes) resulted in insufficient power to draw any conclusion about the exposure-response relationship.

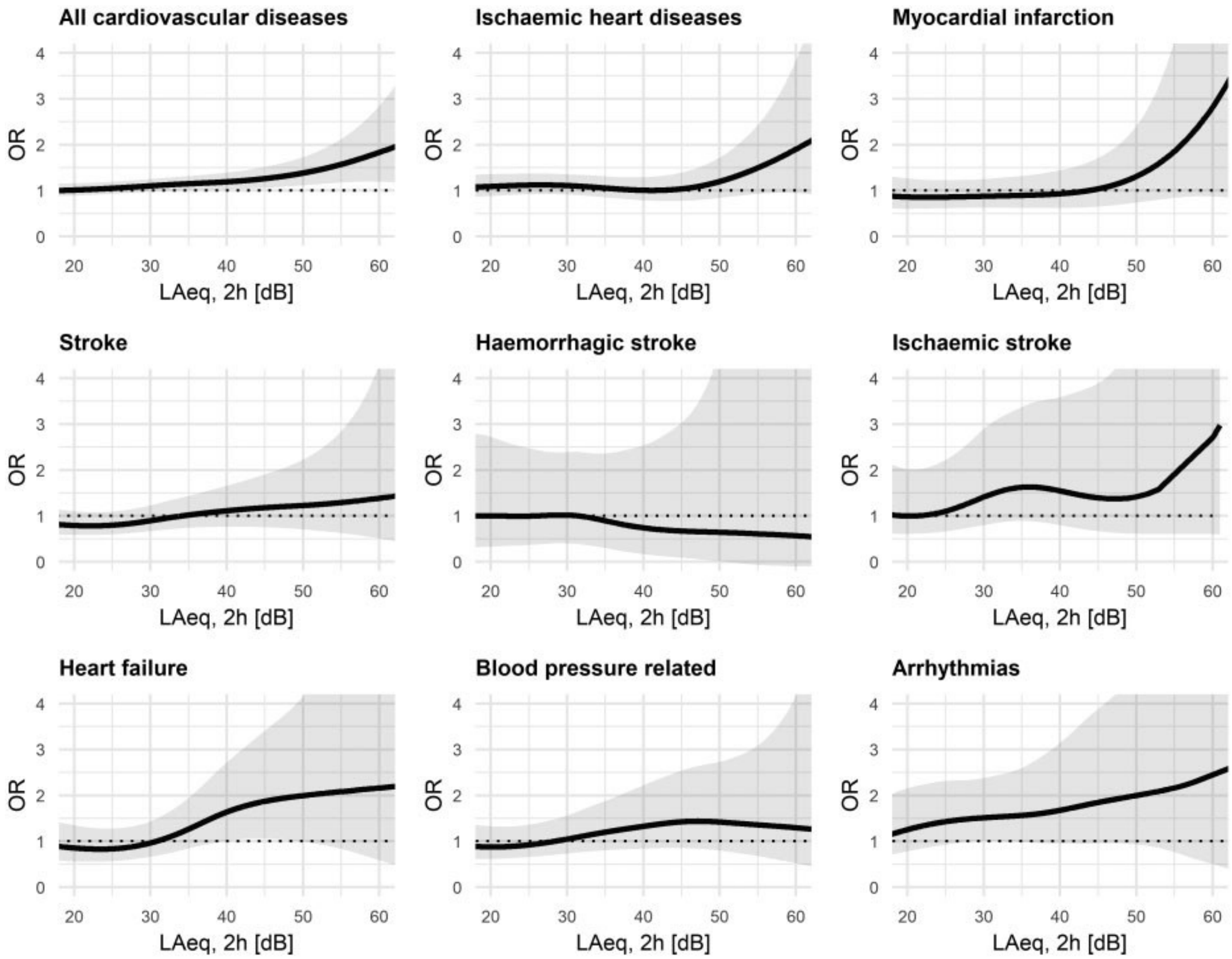


Figure 2: Odds of night-time mortality in relation to 2-hour L_{Aeq} levels.

2.37 The odds of mortality were significantly stronger among females than males, especially for arrhythmias. The researchers estimated that 782 out of 24,886 deaths in the study population could be attributed to aircraft noise (approximately 3%). The association between aircraft noise and night-time cardiovascular deaths was significantly stronger for people living in quiet areas compared to areas with higher night-time levels of road and railway noise, and also for people living in older buildings, most likely with less effective sound insulation. The association between 2-hour L_{Aeq} and mortality tended to be stronger with decreasing education level and socio-economic status, as well as older age. For daytime deaths, no consistent risk increase was observed.

2.38 The study findings suggested that night-time aircraft noise events may trigger cardiovascular deaths, which would explain 3% of all cases of death from cardiovascular cause in the study population living in the vicinity of an international airport if this association was causal. The authors concluded that the study suggests that night-time aircraft noise exposure may be of particular importance in relation to IHD and heart failure, as is also found for long-term exposures.

2.39 De Luque Villa et al authored a paper on noise and sleep quality in communities living around El Dorado International Airport in Bogota, Columbia. This study examined the impact of environmental noise as the result of airport activities, on the quality of life in communities. Noise maps were created from over 60 monitoring points in the Fontibón District of Bogotá and Funza's rural area, and therefore a spatial pattern of noise exposure was obtained.

2.40 To assess sleep quality, The Pittsburgh sleep quality index was adapted to Colombia (PSQI-CV) in order to identify sleep disturbances in the communities. This is a well-established and widely used questionnaire, comprising 19 self-assessment questions and 5 questions directed at the roommate or bed partner, with only the first 14 used to obtain the overall score. There are seven categories of question, relating to: subjective sleep quality, latency, duration, efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The sum of the scores of these components gives a total score that varies between 0 and 21 points, with a score of less than 5, called "No sleep problems", between 5 to 7 called "Needs medical attention", between 8 and 14 called "Needs medical attention and treatment" and over 15 or higher called "Serious sleep problem". Therefore, the higher the score, the lower the quality of sleep.

2.41 The sound pressure levels were compared to the Colombia regulation threshold, shown in Table 1, which dictates the maximum environmental noise levels allowed for various zones within the region.

Zone	Subzone	Maximum allowed environmental noise levels – dB(A)	
		Day	Night
Zone A. Quietness and silence	Hospitals, libraries, day cares, nursing and geriatric homes.	55	45
Zone B. Quietness and moderate noise	Residential zones or exclusively intended for housing, hotel and lodging development.	65	50
	Universities, primary and high schools, study and research centers.		
	Parks in urban zones other than outdoor mechanical parks.		
Zone C. Intermediate restricted noise	Zones with permitted industrial uses, such as industries in general, port areas, industrial parks, free zones.	75	70
	Zones with permitted commercial uses, such as shopping centers, stores, venues or commercial facilities, automotive and industrial mechanics workshops, sport and recreational centers, gyms, restaurants, bars, taverns, discos, bingos casinos.	70	55
	Zones with permitted offices use. Zones with institutional use.	65	50
	Zones with other related uses such as mechanical outdoor parks, zones for public outdoor shows, streets, routes and highways.	80	70
Zone D. Rural or suburban zones of quietness and moderate noise	Residential suburban zone.	55	45
	Rural zone inhabited for agricultural exploitation.		
	Outdoor leisure and relaxation zones such as national parks and natural reserves.		

Table 1: Maximum environmental noise levels (dBA) permitted in Columbia. (Source: Ministry of Environment and Sustainable Development (Colombia), 2006).

2.42 The results indicated that during the daytime, 60% of the sampling points had sound pressure levels below the maximum allowed, but at night-time, only 18% complied with the thresholds. The PSQI-CV results suggested that 87% of the population surveyed in the study area had sleep disturbances. Although noise from other sources, such as road traffic, was measured in Fontibón in the Florida District, the field measurements found that that the only source of noise was the sound of aircraft landing at the El Dorado International Airport.

2.43 The authors concluded that the airport noise mitigation strategies are not effective, and co-ordination between El Dorado Airport and surrounding communities for land use planning is urgently needed in order to reduce noise exposure of the population.

Night-time aircraft noise indexes/models

2.44 Tagusari et al published a paper on the development of a new night-time noise index. This study aimed to develop a new night-time noise index based on neurophysiology and epidemiology. The study involved deriving a formula for predicting the noise effects on sleep based on a neurophysiological model of brainstem sleep regulation, where awakening was associated with greater electrical potentials in the brainstem.

2.45 The researchers then investigated the noise effects on sleep using the results of an epidemiological study that was conducted in the vicinity of the Kadena military airfield in Okinawa, Japan. Thirty volunteers participated in the study. Vibrations of whole-body movements were recorded using Sheet-Shaped Sleep Monitors (SSSM) for 26 consecutive nights. An SSSM is objective, non-invasive, inexpensive, and has a high time resolution, which is applicable to both short- and long-term measurements. Further, this method enables the investigation of awakening reactions in a volunteer's bedroom. Moreover, this method for measuring whole-body movements may be more favourable than approaches that only measure wrist movement, such as actigraphy. The onset of motility, which was defined by monitor vibrations, was used to index awakening reactions.

2.46 The authors explain that the statistical model developed in the study could correctly predict the fluctuating risk of the onset of motility. They claim that the new index, which is the mean of the sound level above 60 dB, can be successfully used, irrespective of the duration of noise exposure. It was concluded that a new night-time noise index has been derived for evaluating the noise effects on sleep. Furthermore, this is the first study to explain the noise effects on sleep with the consideration of neurophysiology and epidemiology.

2.47 Lechner et al published the results of an Austrian study that involved applying the noise equivalents model for aircraft, rail and road traffic to self-reported sleep disturbance. The authors propose that the cumulative effects of multiple noise sources need to be measured and considered. Models have been developed such as the "dominant source" model and the "annoyance equivalents" model (Miedema), which enable the assessment of the overall noise annoyance caused by multiple transportation sources. The annoyance equivalents model is for annoyance from transportation noise but does not relate to sleep disturbance.

2.48 van Kamp et al. on behalf of the IGCB suggested a meta-analysis for self-reported sleep disturbance for the combination of all transport sources. In this study, secondary data from the project "Total Noise Investigation Innsbruck" was used, with the aim of the study to investigate whether the noise equivalents model is also applicable for self-reported sleep disturbances.

2.49 Over 1,031 face-to-face interviews were conducted, and classified into three levels of exposure to road, rail and aircraft noise. The noise exposure groups were ranked using L_{den} groups of <45, 45–55, >55 dB. Logistic regression analysis was used to predict source-specific exposure-response curves for percentage highly sleep disturbed in relation to L_{night} levels. The exposure-response curves were adjusted for self-reported noise sensitivity, access to a quiet façade, and existence of noise control windows.

2.50 The exposure to road traffic noise ranged from 15 to 63 dB L_{night}, the exposure to railway noise ranged from 11 to 63 dB L_{night}, and the range of exposure to aircraft noise was 8–48 dB L_{night}. Exposure-response relationship curves for "highly sleep disturbed" at a cut-off value of 72% for all traffic noise sources are illustrated in Figure 3.

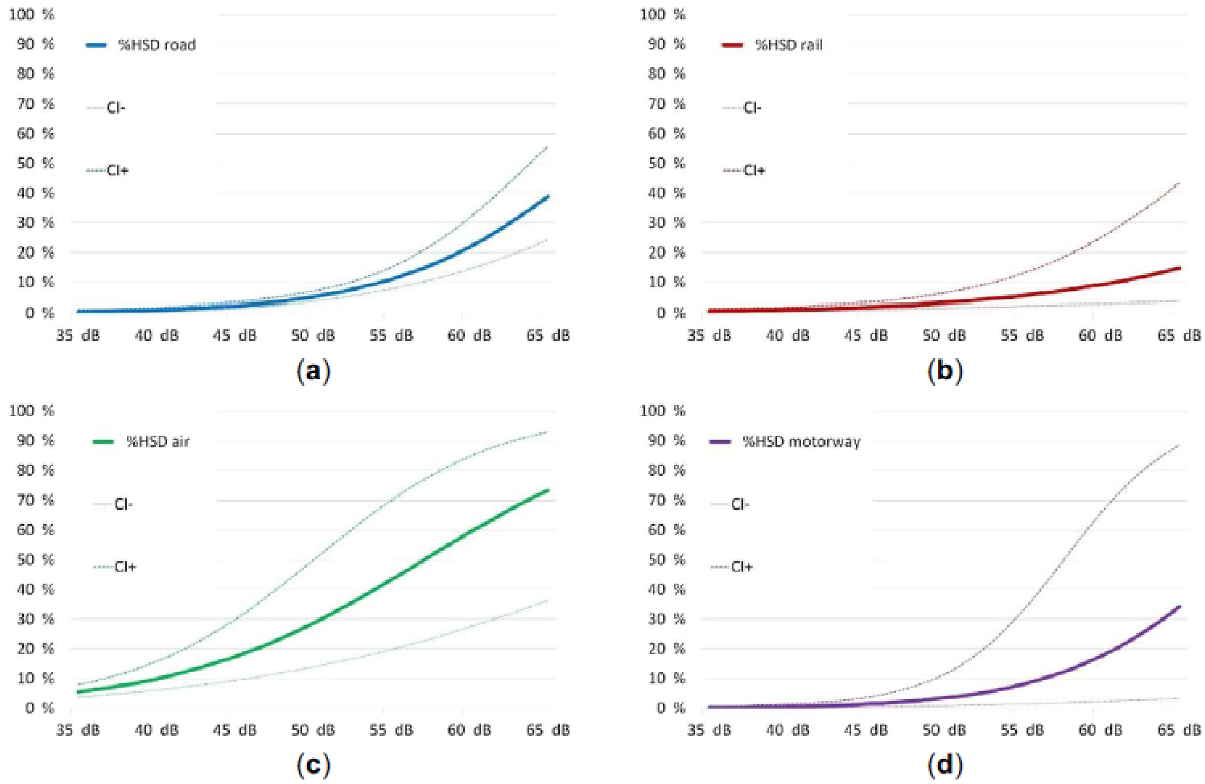


Figure 3: (a) Exposure response relationships and their confidence intervals for the percentage of highly sleep disturbed for road, (b) rail and (c) air traffic noise, and (d) for the subgroup motorway noise.

2.51 The exposure-response curve is steeper for aircraft noise and self-reported sleep disturbance compared to the other noise sources. The rail noise curve is flatter than the road noise equivalent, especially above 50 dB L_{den}, where there is a steeper rise in the curve for road traffic. A percentage of 10% "highly sleep disturbed" is expected at 54 dB L_{night} road traffic noise and 61 dB rail traffic noise. This suggests a 7 dB bonus for self-reported sleep disturbance in relation to railway noise. The 10% highly sleep disturbed level corresponds to approximately 42 dB L_{den} in this study.

2.52 The authors compared these exposure-response curves to other published curves from the WHO (2018), SiRENE (2019) and Miedema (2001) studies. The exposure-response function for air traffic noise in Innsbruck is very similar to the one found in the SiRENE study. Both curves are higher on the scale than the recent WHO curve (Figure 4). A further finding was that the same fit can also be achieved by using a dominant source model.

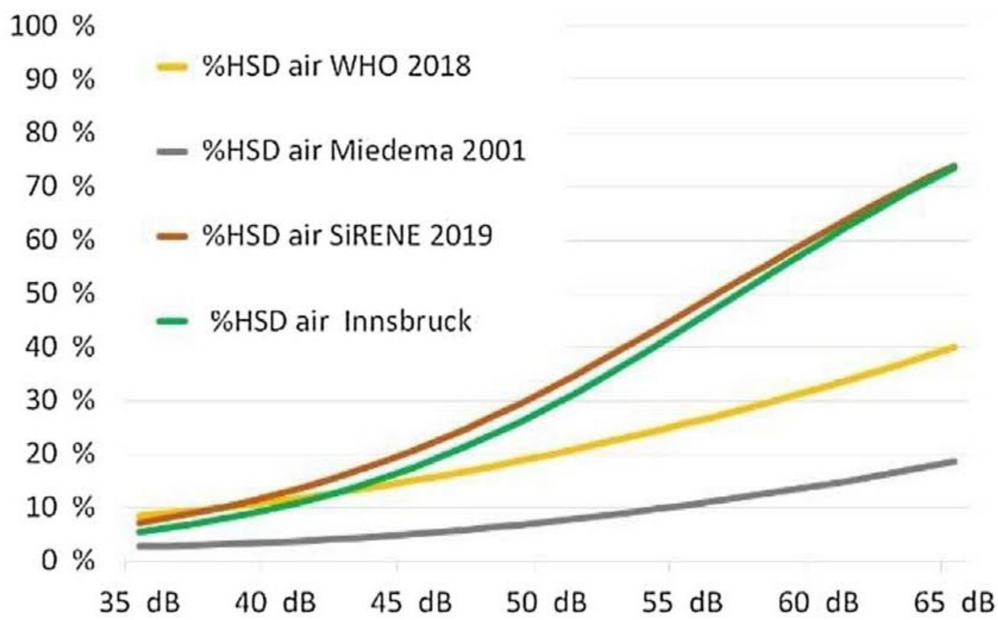


Figure 4: Comparison of exposure-response curves with each other, (b) with WHO 2018, SiRENE 2019 and Miedema 2001 for air traffic noise.

2.53 The authors concluded that a sleep disturbance equivalents model for multiple transportation noise sources is suitable for estimating total sleep disturbance within the same range as the annoyance equivalents model. The findings suggest that air traffic at night results in a much higher level of self-reported sleep disturbance than the other transportation noise sources. When comparing the results from this study to those provided by the WHO, it is suggested that it is worthwhile to derive local exposure-response relationships in order to set noise limits.

FAA Neighbourhood Study

2.54 The Federal Aviation Administration (FAA) conducted a nationwide survey on annoyance due to aircraft noise. The FAA's aim was to obtain up-to-date information regarding aircraft noise annoyance in the U.S. as the last in-depth survey was conducted in 1992, which resulted in re-evaluation of the Schultz exposure-response relationship. Since then, the publication of other exposure-response relationships worldwide suggests that annoyance due to aircraft noise has also risen in the U.S.

2.55 A National survey was conducted in communities around airports in the U.S. to assess the relationship between aircraft noise and annoyance with the aim to produce a new exposure-response curve. The survey was sent to 40,000 households over a 12-month period from October 2015 to September 2016, and over 10,000 people responded and completed the survey. The questionnaire related to thirteen environmental issues, of which aircraft noise was one. It was not made explicit that this was an aircraft noise study, in order to minimise bias. A follow-up telephone survey was also offered to the same participants, of which there was a 2,000 response rate.

2.56 20 airports were selected for the survey, following inclusion criteria such as being located in each of the eight FAA regions, on average 300 flight operations, aircraft fleet mix ratio, average daily temperature between 55- and 70-degrees Fahrenheit. A DNL of 50 dB was chosen as the minimum noise exposure for people to be eligible for inclusion in the survey. Table 2 shows the number of people exposed within each noise category.

Total Number of Survey Responses	
DNL dB Categories	**Survey Respondents**
50-55	3,592
55-60	3,481
60-65	2,016
65-70	914
70+	325
Total	**10,328**

Table 2: Number of respondents within each noise category (DNL).

2.57 The questionnaire included the standardised annoyance question: "Thinking about the last 12 months or so, when you are here at home, how much does each of the following bother, disturb, or annoy you?" For this question there were 13 different environmental topics (e.g. litter, neighbourhood noise, lack of green spaces), and survey respondents were asked to rate their annoyance on a scale from one to five (five being most annoyed). One of the categories was "Noise from Aircraft."

2.58 The new exposure-response curve was produced from the annoyance responses and modelled aircraft noise levels. The results indicated that there had been an increase in the number of people who are Highly Annoyed (HA) by aircraft noise over the entire range of noise levels. This is shown in Figure 5. The responses 4 and 5 on the 5-point scale (60%) were classed as Highly Annoyed in this study.

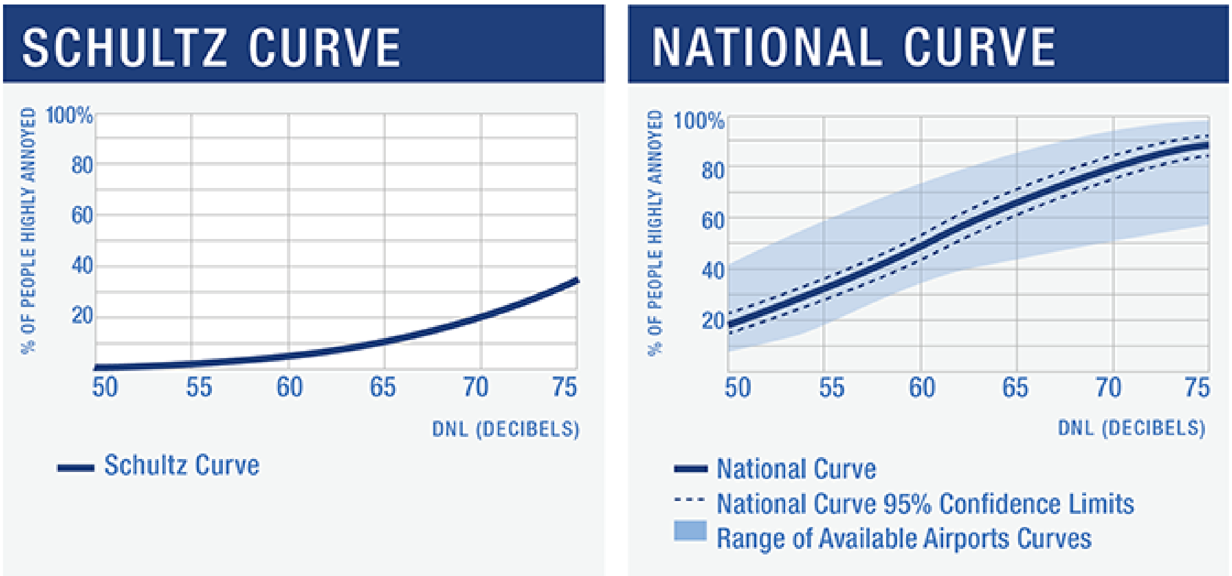


Figure 5: Comparison of the Schultz curve and the new National Curve for aircraft noise (DNL) and annoyance responses from the survey.

2.59 The results indicate that 20% of people are Highly Annoyed at 50 dB DNL, and this figure rises with an increase in aircraft noise level. The data is being further analysed for reasons that may explain why there is such a substantial increase in annoyance levels now compared to previously. The authors found that the majority of phone survey respondents who were likely to be annoyed by aircraft noise indicated that they have experienced being "Startled", "Frightened", or "Awakened" by aircraft at home. Those who were bothered, disturbed, or annoyed by "General Traffic Noise" or "Smells" were also more likely to be annoyed by aircraft noise. The FAA is now inviting views and comments from the public on all aspects of the survey.

Aircraft noise annoyance and noise sensitivity in the association between aircraft noise levels and hypertension risk

2.60 Baudin et al published a study on the role of aircraft noise annoyance and noise sensitivity in the association between aircraft noise levels and hypertension risk. Although there have been many studies that have examined the effects of aircraft noise exposure on cardiovascular disease and hypertension, there have been far fewer studies that have considered the effects of aircraft noise annoyance and noise sensitivity in regard to cardiovascular risk or as mediating or modifying factors[1].

2.61 There were two aims of this study:

1) to investigate the risk of hypertension in relation to aircraft noise annoyance or noise sensitivity

2) to examine the role of modifier or mediator of these two factors in the association between aircraft noise levels and the risk of hypertension.

2.62 In this study, data was pooled from two major European studies on aircraft noise and health that used a similar methodology: HYENA (HYpertension and Exposure to Noise near Airports) and DEBATS (Discussion on the health effects of aircrafts noise) to investigate the impact of aircraft noise annoyance and noise sensitivity on hypertension risk. The researchers also investigated their modifying and mediating role on the relationship between aircraft noise levels and hypertension, as the larger sample sizes produced by pooling the data helped provide increased statistical power to explore interactions.

2.63 The combined dataset included some of Europe’s busiest airports, from the HYENA study conducted in 2004-2006 with over 4,800 participants: London Heathrow (United Kingdom), Berlin Tegel (Germany), Amsterdam Schiphol (the Netherlands), City Airport Bromma and Stockholm Arlanda (Sweden), Milan Malpensa (Italy), and Athens Elephterios Venizelos (Greece). From the DEBATS study in 2013 with over 1,200 participants: Paris Charles de Gaulle, Lyon-Saint-Exupéry, and Toulouse-Blagnac (France).

2.64 Both studies conducted a face-to-face interview with measurements of blood pressure (BP), weight and height. The questionnaire included items on socio-demographic information; smoking, alcohol consumption, physical activity and other lifestyle factors; medical history and medication use; and sleep disturbance, annoyance by aircraft noise, and noise sensitivity.

2.65 Annoyance due to aircraft noise was measured in both studies by the ISO/ICBEN question "Thinking about the last 12 months, when you are here at home, how much does aircraft noise bother, disturb or annoy you?". In HYENA, the scoring was numeric with range 0–10 and assessed separately for night-time and daytime exposure. Night-time and day-time scores were averaged and ‘highly annoyed’ was defined as an average score ≥8. In sensitivity analyses, the highest score of day and night was used. In DEBATS, the scoring did not

[1] A mediator variable explains the process through which two variables are related, while a moderator variable affects the strength and direction of that relationship.

distinguish between day and night and was verbal, with answers being extremely, very, moderately, slightly or not at all annoyed. ‘Highly annoyed’ was here defined as reporting ‘extremely’ or ‘very’ annoyed.

2.66 5,886 participants were included in the combined studies, with completed information for all the confounders included in the model such as age, gender, education level, physical activity, BMI, alcohol consumption, and country of residence. The results indicated that 51% of the participants were classified as hypertensive: it varied between 35% in France and 60% in Greece. Participants from the UK were the most exposed to aircraft noise at night (49.3 ± 10.5 dBA L_{night}), compared to participants from Italy who were the least exposed (35.4 ± 6.4 dBA). Almost 20% of the participants reported being highly annoyed by aircraft noise: Greek participants were the most annoyed by aircraft noise (43%), whereas participants from Sweden were the least annoyed (10%). About 35% of the participants reported low sensitivity to noise, 32% medium sensitivity and 33% high sensitivity. Italian participants were the most sensitive to noise, whereas participants from Sweden were the least sensitive to noise.

2.67 A 10 dBA increase in night-time aircraft noise exposure (L_{night}) was significantly, albeit weakly, associated with an increased risk of hypertension (RR = 1.03, 95%CI 1.01–1.06) and there was no difference between the countries. Aircraft noise annoyance was also significantly associated with the risk of hypertension (RR = 1.06, 95%CI 1.00–1.13 for highly annoyed people compared to those who were not highly annoyed) with no difference between countries.

2.68 The interaction between noise sensitivity and country was significant, showing differences in RRs among countries. All RRs were very close to 1 in all countries except in the UK and France (in the UK, RR =1.08, 95%CI 0.87-1.34 for medium sensitivity compared to low sensitivity, RR = 1.29, 95%CI 1.05-1.59 for high sensitivity compared to low sensitivity; in France, RR = 1.00, 95%CI 0.61-1.65 for medium sensitivity compared to low sensitivity; RR = 1.11, 95%CI 0.68-1.82 for high sensitivity compared to low sensitivity). The interaction between aircraft noise annoyance and aircraft noise levels at night (L_{night}) was not significant (p = 0.36), nevertheless the association between aircraft noise levels at night (L_{night}) and the risk of hypertension was a little higher for highly annoyed participants (RR =1.06, 95%CI 0.95-1.18 for a 10-dB(A) increase in L_{night}) compared to not highly annoyed participants (RR = 1.02, 95%CI 0.99–1.06).

2.69 The interaction between noise sensitivity and aircraft noise levels at night (L_{night}) was statistically significant ($p < 0.01$): the association between aircraft noise levels at night (L_{night}) and the risk of hypertension increased with the level of noise sensitivity and was significant only among highly sensitive participants (RR = 1.00, 95%CI 0.96–1.04; RR =1.03, 95%CI 0.90–1.11; RR = 1.12, 95%CI 1.01–1.24, with a 10-dB(A) increase in L_{night} for low, medium, and high sensitive people respectively.

2.70 The authors concluded that the results were consistent with previous findings, suggesting that aircraft noise levels are associated, although weakly, with the risk of hypertension, and aircraft noise annoyance is associated with hypertension risk. They also suggest a possible modifying effect of aircraft noise annoyance in the relationship between aircraft noise exposure and the risk of hypertension. This is the first study to examine the role of noise sensitivity in the relationship between aircraft noise levels and hypertension risk, finding that this association was higher among highly sensitive participants. The authors stress the importance of future studies of this nature to take noise annoyance and sensitivity into account, in particular by using appropriate statistical models related to mediation analysis and causal inference.

2.71 A further publication from this study focussed on the role of aircraft noise annoyance and noise sensitivity in the association between aircraft noise levels and medication use.

2.72 The participants were asked to report all prescribed and non-prescribed medications used in the last 2 weeks (HYENA) and the last 12 months (DEBATS) prior to the interview. Each medication was coded according to the Anatomical Therapeutic Chemical Classification System (ATC) as proposed by the WHO.

2.73 The results indicated that there was a significant association between aircraft noise levels at night and antihypertensive medication only in the UK (OR = 1.43, 95%CI 1.19–1.73 for a 10 dBA increase in L_{night}). No association was found with other medications. Aircraft noise annoyance was significantly associated with the use of antihypertensive medication (OR = 1.33, 95%CI 1.14–1.56), anxiolytics (OR = 1.48, 95%CI 1.08–2.05), hypnotics and sedatives (OR = 1.60, 95%CI 1.07–2.39), and antasthmatics (OR = 1.44, 95%CI 1.07–1.96), with no difference between countries.

2.74 Noise sensitivity was significantly associated with almost all medications, with the exception of the use of antasthmatics, showing an increase in ORs with the level of noise sensitivity, with differences in ORs among countries for the use of antihypertensive medication only. The results also suggested a mediating role of aircraft noise annoyance and a modifying role of both aircraft noise annoyance and noise sensitivity in the association between aircraft noise levels and medication use. The association between aircraft noise levels and antihypertensive medication were significantly higher in highly sensitive and in highly annoyed participants. The authors suggest that future studies of the health effects of noise exposure have to consider both noise annoyance and noise sensitivity.

2.75 Baudin also published findings from this study, regarding self-related health status in relation to aircraft noise, annoyance and noise sensitivity. In this paper, only results from the DEBATS study, around 1,240 respondents around three

French airports (Paris-Charles de Gaulle, Lyon Saint-Exupéry, and Toulouse-Blagnac) were included. Self-rated health status (SRHS) was measured with a single question in the face-to-face interview: “In general, would you say that your health is excellent, good, fair, or poor?”. The participants who responded with a fair or poor SRHS were compared to those whose SRHS was good or excellent.

2.76 Noise sensitivity was assessed with the question: “Regarding noise in general, compared to people around you, do you think that you are: much less sensitive than, or less sensitive than, or as sensitive as, or more sensitive or much more sensitive than people around you?”. Participants who said they were much more or more sensitive than people around them were classed as highly sensitive to noise. They were compared to participants who said they were much less, less or as sensitive as people around them who were considered not highly sensitive to noise.

2.77 The percentage of respondents rating a fair/poor SRHS was 15% for men and 16% for women. This was similar among all aircraft noise categories for women but varied from 9% in the < 50 dBA category to 20% in the 55–59 dBA category for men.

2.78 The results indicated that there was a significant association between aircraft noise levels and a fair/poor SRHS, only in men (OR= 1.55, 95%CI 1.01–2.39, for a 10 dBA increase in L_{den}). This relationship was higher in men highly sensitive to noise (OR=3.26, 95%CI 1.19–8.88, for a 10 dBA increase in L_{den}).

2.79 Noise sensitivity was significantly associated with a fair/poor SRHS in women (OR=1.74, 95%CI 1.12–2.68) and at borderline significance in men (OR=1.68, 95% CI 0.94–3.00). Aircraft noise annoyance was associated with a fair/poor SRHS only in men (OR=1.81, 95%CI1.00–3.27).

2.80 The authors concluded that the results suggest an association between aircraft noise exposure and a fair/poor SRHS. After adjusting for potential confounding factors, the results suggest that the men who were exposed to higher aircraft noise levels were more likely to report a fair/poor SRHS. The results support the hypothesis that noise sensitivity would have a moderating role in this association, which would not be the case for noise annoyance. The mediating effect of annoyance cannot be ruled out. It is suggested that more studies of this nature are needed in future to support these conclusions.

ICCAN Lockdown Survey on aircraft noise

2.81 The Independent Commission on Civil Aviation Noise (ICCAN), obtained data on attitudes to aircraft noise during lockdown throughout the Covid-19 pandemic. Using IPSOS Mori for data collection, over 2,000 respondents living around Heathrow, Manchester, Gatwick, East Midlands and Edinburgh airports were interviewed in the study between 18th June and 13th July 2020.

2.82 The key questions that were investigated were:

1) Has exposure to aviation noise changed during the 'lockdown' period from respondents' experiences?
2) What are the current attitudes towards aviation noise?
3) Have there been any changes in the extent to which aviation noise bothers, disturbs or annoys people?
4) Are there any factors which are contributing to people's current exposure to aviation noise, e.g. a decrease in other transport noise (rail and road), working from home or spending more time at home/ in garden?

2.83 Respondents resided at addresses that were within postcodes for the 2018 average summer day 54 dB L_{Aeq},16h contours (2019 for East Midlands) around the selected five airports. The survey was conducted by telephone, which involved a 15-minute questionnaire. There were 2,006 respondents, aged 18 years or over. The choice of airports was based on the volume of air traffic movements and was split into three bands: 'small' including Edinburgh and East Midlands, 'medium' including Gatwick and Manchester, and Heathrow being classed as 'large'. The sampling method was structured, with quotas for age, gender and working status and to ensure enough numbers of responses from the small and medium airports. The data was weighted to the population profile of each airport band.

2.84 The main findings from the study were that 92% of respondents stated they could hear aircraft noise prior to lockdown, and 86% reported hearing less aircraft noise during lockdown. Prior to lockdown, 66% were bothered by aircraft noise during the day and evening (07:00-23:00), during lockdown 61% of respondents reported not noticing a change to flight paths. Before lockdown, 44% of people were bothered or disturbed during the night period (23:00-07:00) compared to 13% during lockdown.

2.85 The percentage of respondents reporting that they were bothered by daytime aircraft noise before lockdown fell from 66% to 28% during lockdown. The study found respondents in younger age groups were less likely to report hearing aircraft noise before lockdown compared to older participants. 35% of 18-34-year olds reported hearing a lot of aircraft noise, compared to 48% of 35-54-year olds and 48% of 55 years or older. When the younger groups did report hearing aircraft noise, they were less bothered by it than the older groups.

2.86 48% of respondents agreed that they do not mind if aviation noise goes back to pre-lockdown levels, while 38% disagreed. 66% of respondents agreed that the environment should be given higher priority than supporting the recovery of the aviation industry, while only 15% disagreed. The younger respondents were more likely to agree that the environment should be given higher priority than the recovery of the aviation industry (72% of 18 to 34-year olds compared to 62% of 35 to 54-year olds and 65% of 55+ year olds).

2.87 ICCAN now intends to use these findings when discussing the recovery of the aviation industry, and repeat the survey to capture possible changing attitudes, as flight movements begin to increase following the peak of the Covid-19 pandemic.

Chapter 3
Summary

3.1 This report has provided a summary of some of the main findings in the past six months (September 2020 – March 2021) with regards to aircraft noise and health effects. Summary reports such as these are published on a six-monthly basis and continue to include all health outcomes in relation to aircraft noise exposure. The next update report will contain findings from the ICBEN Congress being held as an E-Congress in June 2021 in Stockholm.

Chapter 4

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