Environmental Research and Consultancy Department

Civil Aviation Authority

Aircraft Noise and Health Effects – a six monthly update

CAP 1971

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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 March 2020 to September 2020 and includes relevant findings presented at the Internoise Congress held in August. Due to the Covid-19 pandemic, this year Internoise was held as an E-Congress online. The ICBEN (International Commission on Biological Effects of Noise) Congress, due to be held in Stockholm in June this year has been postponed to 2021.

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

Internoise Findings

2.1 The Internoise Congress was held on 23-26th August as an E-Congress due to the Covid-19 pandemic. There were fewer papers relating to aircraft noise and health this year than we normally would have expected, probably due to ICBEN being scheduled in the same year, and authors choosing to present there (now postponed until 2021). The relevant findings that have been made available relating to aircraft noise and health outcomes are presented in this chapter.

2.2 **Spilski et al** authored a paper asking whether we need different metrics to predict the effects of aircraft noise on children's wellbeing and health. CAP1883 included reference to a similar paper by this author, which looked at the idea of using different aircraft noise metrics to predict annoyance for different groups of people. Although L_{eq} and L_{den} are the most commonly used metrics for annoyance studies, the authors suggest that other metrics such as Number of aircraft noise events above a certain threshold (NA), L_{max} and Emergence[1] should not be ignored as they may explain further the variance of 19% that the WHO found between aircraft noise levels and raw annoyance scores. The study re-examined the NORAH dataset with the aim of assessing the effectiveness of alternative noise metrics and differences in the level of relationships in different groups of people (children, parents and teachers) and in different settings (school: workplace or learning environment; residential environment).

2.3 The Internoise paper examined the different metrics with regard to children's annoyance at home. The authors have previously reported that in the school context, based on the NORAH data, analysis of further noise metrics can significantly increase the explained variance of the outcomes (reading performance, aircraft noise annoyance in school). In this study, they used alternative acoustic metrics for the home context, to improve explained variance in the outcome variables (children's well-being, health, and aircraft noise annoyance at home). The aim was to examine the suitability of different noise exposure metrics (L_{Aeq}, L_{den}, L_{Amax}, Emergence, NAT55 to NAT80) for analysing the associations between aircraft noise and annoyance, well-being and health in the home context.

2.4 Over 1,200 children from 29 primary schools were included in the study, with a mean age of 8 years 4 months. 976 complete data sets were analysed.

[1] Emergence is the difference between L_{Amax} and L_{Aeq}

Table 1: Selected NORAH outcome variables concerning children's annoyance due to aircraft noise exposure at home, health-related quality of life, physical diseases and developmental abnormalities. (Taken from Internoise proceedings)

	Outcome variable	Psychometrics/ Questions	Response scale
Child judgments	Index "Annoyance due aircraft noise at home"	*CR* = .83, α = .80; *AVE* = .71	4-point scale (*strongly disagree, disagree, agree, strongly agree*)
	Physical well-being (single variables)	PWB 1: Last week I had a headache and stomach ache. PWB 2: Last week I felt sluggish and tired.	3-point scale (*never, sometimes, often*)
	Psychological (mental) well-being (single variables)	MWB 1: Last week I laughed a lot and had a lot of fun. MWB 2: Last week I was bored.	3-point scale (*never, sometimes, often*)
Parental judgments	Physical diseases and developmental disorders	e.g., middle ear inflammation, asthma, neurodermatitis, migraine, attention disorders, speech and language disorders	3-point scale (*no, never; yes, once; yes, several times*)

Notes. CR = composite reliabilities, α = Cronbach's α, *AVE* = average variance extracted

2.5 Table 1 shows the items concerning health-related quality of life and annoyance due to aircraft noise exposure. The children were tested in groups and had the questions read out loud to them, with a combination of pictures and numbers for ease of understanding. They also took a questionnaire home for their parents to fill in on the children's well-being, health related outcomes and potential confounding factors such as socio-economic status.

2.6 The results indicated that no significant association was found between aircraft noise levels at home and children's wellbeing, except for one measure of psychological wellbeing: "I was bored last week", which was strongest for L_{Aeq} ($p < 0.001$).

2.7 No association was found between aircraft noise exposure at home and children's health (physical diseases and developmental disorders).

2.8 The regression models revealed significant associations between aircraft noise exposure at home and children's aircraft noise annoyance (all p's < 0.001). This result was consistent for all nine aircraft noise metrics. The associations were lowest for the Emergence and NAT indicators ≥55 <60 (β = 0.172 and 0.171), and highest for L_{Aeq}, L_{den} and L_{Amax} (β = 0.404 to 0.429). The authors found no evidence that other exposure measures than L_{Aeq} could better relate to annoyance judgments. There was no evidence that combined models with

several exposure metrics led to better prediction of the outcomes for annoyance, well-being and various health outcomes.

2.9 The results indicated that the outcomes are not consistent when investigating children's annoyance and health outcomes in relation to aircraft noise. The authors suggest that the present results indicate that research on noise exposure effects is very complex and there is a need to consider different contexts (home versus school), different dependent variables (well-being, health, cognition) and different metrics (e.g. L_{Aeq}, NAT). Further research is needed to determine under which conditions effects could be found, and under which circumstances there is no effect.

2.10 **Lavia et al** from the UK authored a paper on Soundscape, engagement and planning practices within airport expansion projects in the UK. This paper formed part of Lavia's Doctoral thesis, investigating the role of soundscape management and public wellbeing with the planning processes for aviation expansion at two airports in the UK.

2.11 The study examines how people respond to sound environments, whether they are already in existence, are being imagined, or has been part of a development process. As found in all research relating to noise or sound, the importance of non-acoustic factors cannot be overlooked. Non-acoustic factors can contribute to a wide range of responses to the same sound, hence the need to control for them as much as possible within analyses.

2.12 Within soundscape management, the non-acoustic factor "perceived control" is known to be very important and can impact how engagement in planning processes are perceived by stakeholders. The element of perceived control can also influence wellbeing, and as such is an important consideration when planning and developing. This study investigates stakeholders' perceived control and the impact on effective engagement in the context of planning processes for airport expansion projects in the UK.

2.13 The paper discusses how non-acoustic factors are balanced with stakeholder engagement in the UK. For sustainable development this involves engagement with stakeholders concerning the possible mitigation strategies available for aircraft noise and communities. As mentioned above, the presence of non-acoustic factors and the subjective nature of one's response to sound serves to further challenge this process.

2.14 Lavia quotes the WHO statements that non-acoustic factors:

i) are an 'important possible confounder in both exposure-response functions (ERFs) between noise levels and critical health effects and the effects of acoustic interventions on health outcomes';

ii) may include attitude to the noise source, attitude to/trust of the noise maker/authority, and ability to cope with noise;

iii) may account for 'up to 33% of the variance' in noise annoyance studies.

2.15 The paper discusses the role of Aviation Noise Impact Management through Novel Approaches (ANIMA), which identified the need for engagement efforts to focus holistically on 'annoyance outcomes in addition to reducing noise exposure' and that 'to date these contributions had only been partially addressed'. Specifically, they identified the research need to 'assess the impact of engagement processes associated with aircraft noise management interventions for their ability to modify non-acoustic factors known to exacerbate the annoyance response [e.g. attitudes to source, trust and its relationship with annoyance levels]' and that therefore, 'it can be hypothesised that by reducing the impact of non-acoustic factors, for example by improving trust, annoyance can be reduced and wellbeing improved'.

2.16 The paper explains that soundscape research is relatively new, and there is a need for more research into real world applications. Relatively few studies have looked at soundscape concepts and aircraft noise. This study focussed on perceived control due to the known relationship between control and trust. The author hypothesises that: "control over a noise source has long been acknowledged as a primary non-acoustic factor in people's response to noise. Therefore, given the crucial role it plays in facilitating effective stakeholder engagement, perceived control is linked to reducing annoyance and improving wellbeing".

2.17 This study is being conducted within the context of two current aviation expansion projects in the UK. The authors explain that a soundscape conceptual framework will be proposed for implementing effective stakeholder engagement within a soundscape design and planning process for this context. The research questions being explored are:

1) What methods/activities support/or not stakeholders feelings/perceptions regarding the effectiveness of the engagement process(es) and why/not?;

2) What are the criteria/components of these/this method(s)/activit(y)ies that did/not work and why?

2.18 The underlying themes that are explored are:

1) How do/does these/this method(s) support or not perceived control for stakeholders?;

2) How does improved perceived control impact the effectiveness of stakeholder engagement activities?

2.19 Collection of the data for this study is planned to be conducted in the following four ways:

- 1:1 semi-structured interviews of a range of experts from the aviation industry; planning, environment and health practitioners; and engagement specialisms; (this was delayed due to Covid-19)
- online data collection regarding the selected case studies and relevant materials;
- deep-dive naturalistic observation of one of the case studies in-situ;
- focus groups to validate the conceptual framework.

2.20 The work is currently in progress and some data collection has been completed. It is stated that the "main output from this PhD will be a new conceptual framework for engaging stakeholders as co-specifiers/designers, through soundscape management, for airport expansion projects. The outcomes derived from the two aviation cases will set important precedents applicable to other airport expansion projects in the UK."

Chapter 3

Aircraft noise and health outcomes

Annoyance

3.1 **Lefèvre et al** published a study on the relationship between air traffic noise exposure and annoyance in populations living near airports in France. The French study DEBATS (Discussion on the Health Effects of Aircraft Noise) study, included 1,244 residents aged over 18 years around three major French airports (Paris-Charles de Gaulle, Lyon-Saint-Exupéry and Toulouse-Blagnac) in 2013. This paper compared the exposure-response relationship estimated among airports' residents in France with old and new EU standard curves. Investigation into whether non-acoustical factors may explain this annoyance was also undertaken.

3.2 Aircraft noise exposure was placed into four categories in terms of L_{den} < 50, 50–54, 55–59 and ≥60 dBA. Households with home address included in the study area were randomly selected from a phone directory. Once a household was contacted by phone, a participant was randomly selected from within the household. 1,244 participants completed a face-to-face questionnaire on various demographic and socioeconomic detail, along with situational and personal attitudinal information, including noise sensitivity.

3.3 Aircraft noise-related annoyance was assessed using the ICBEN 5-point scale. The non-acoustic factors examined included:

- Age
- Gender
- Education
- Occupation
- Home ownership
- Economic dependency on airport activities
- Use of the noise source
- Noise sensitivity
- Fear of a plane crash

3.4 Other information such as type of dwelling, outdoor spaces and type of windows or roof insulation was also collected as well as expectations regarding quality of life. Satisfaction with living environment was assessed using standardised

questions, and noise-source and authority-related attitudes of people regarding aircraft noise concerns were evaluated.

3.5 Logistic regression models were used to assess the relationship between aircraft noise levels and severe annoyance (%HA). The proportion of highly annoyed people (%HA) was modelled first as a function of noise levels only (M0 model) to enable a comparison with old and new EU standard curves for the prediction of aircraft noise annoyance. A second model (M1 model) was then used adjusting also for non-acoustical factors having a possible influence on noise annoyance.

3.6 For the M0 and M1 models, the percentages of highly annoyed people for different levels of noise were estimated from the predictions to determine the exposure-response relationship.

3.7 The results indicated that 18% of the participants reported to be highly annoyed by aircraft noise (HA), and much more in summer (50%) than in winter (7%). The activities disturbed by aircraft noise that most differentiate between highly annoyed (HA) and non-highly annoyed (non-HA) participants were related to physical and mental recovery (relaxing/resting, sleeping), speech comprehension (conversing, listening), and concentration (reading and intellectual work at home).

3.8 The proportion of highly annoyed participants increased when aircraft noise exposure increased: from 8% in the lowest noise levels (< 50 dBA) to 31% in the highest ones (≥60 dBA). People over 55 years of age were more likely to report to be highly annoyed (22% versus 15% in the < 55 years group).

3.9 The participants declaring to be pessimistic regarding the evolution of the quality of life in their neighbourhood were much more prone to report to be highly annoyed (29% versus 11% for those who are optimistic, neutral or have no idea). People considering themselves much more sensitive to noise than others more often reported severe annoyance (36% versus 19%, 17% and 19% for those who considered themselves more sensitive, as sensitive or less sensitive to noise than others respectively) as well as people declaring to be afraid of a plane crash (25% versus 11% for those who declared not to be afraid of a plane crash). No difference was found in terms of gender, occupational activity, homeownership, economic dependency on airport activities, use of the noise source or other situational factors.

3.10 Figure 1 illustrates the exposure-response relationships derived from the regression modelling analyses and indicates the two DEBATS models compared to the new EU curve (updated in 2018) and the old EU curve as derived by Miedema and Oudshoorn (2001).

3.11 Figure 2 illustrates the exposure-response relationships for severe annoyance due to aircraft noise (HA) for people between 45 and 70 years of age and for people who had resided at their address for at least 5 years, for each of the

univariate (noise only) and multivariate (inclusion of non-acoustic factors) regression models (0 and 1, respectively).

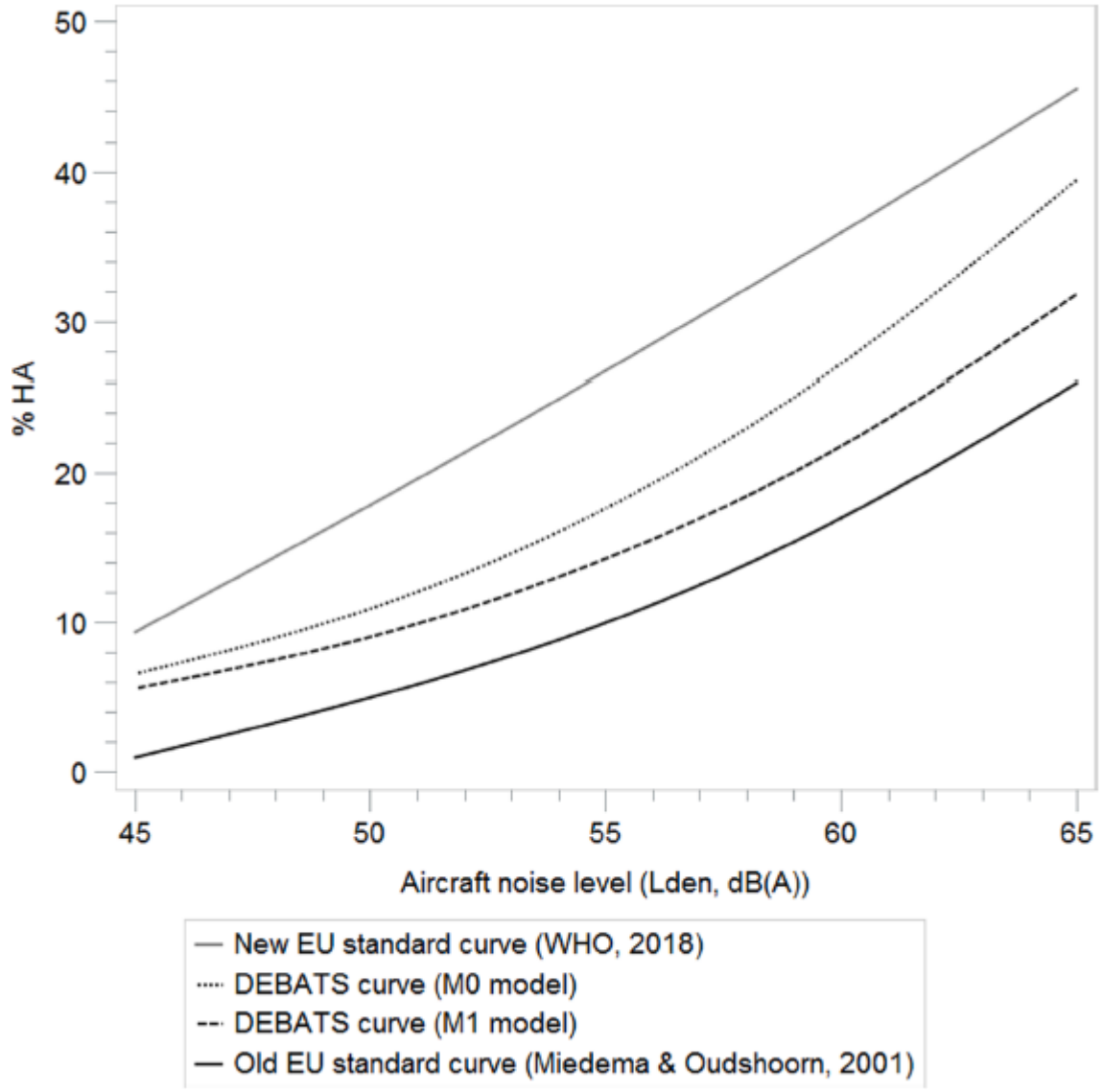

Figure 1: Exposure-response relationships between aircraft noise exposure and severe annoyance due to aircraft noise (HA): comparison between DEBATS and old and new EU standard curves. HA: Highly annoyed. M0: adjusted on aircraft noise exposure only (in terms of L_{den}). M1: adjusted on aircraft noise exposure and non-acoustical factors (age, gender, education, occupational activity, homeownership, economical dependency on airport activities, use of the source of noise, noise sensitivity, fear of a plane crash, type of housing, presence of outdoor spaces, windows or roof insulation, satisfaction with the living environment, source- and authority-related attitudes of people regarding aircraft noise concerns, and expectation regarding the quality of life in the neighbourhood). Taken from Lefèvre et al. (2020)

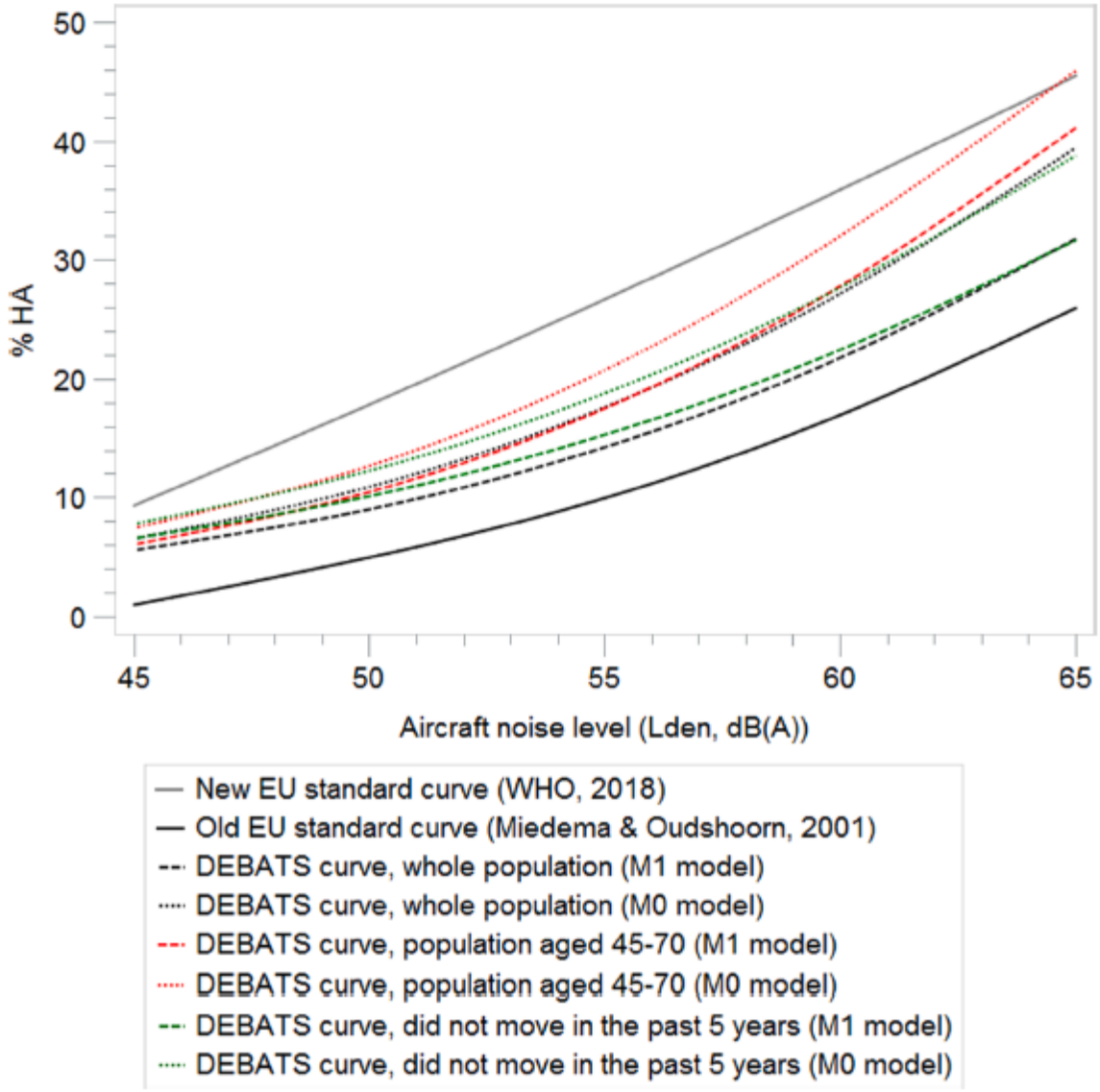

Figure 2: Exposure-response relationships between aircraft noise exposure and severe annoyance due to aircraft noise (HA) for people between 45 and 70 years of age and for people who had resided at their address for at least 5 years. Taken from Lefèvre et al. (2020).

3.12 The results of the study indicate that there is an association between high levels of annoyance and some non-acoustic factors including noise sensitivity, satisfaction and expectations about the living environment, and attitude to the noise source. Annoyance was higher than predicted by the old EU standard curve when estimated with the model including non-acoustical factors in addition to the L_{den}. It was even higher when only noise exposure was considered. However, annoyance was lower in DEBATS than predicted by the new EU standard curve provided by WHO.

3.13 None of the socio-economic characteristics (occupational activity, homeownership, economic dependency on airport activities, and use of the noise source) studied or of the housing factors were associated with severe annoyance.

3.14 The authors discuss that neither changing noise exposure situations around airports nor study population characteristics seem to explain this increase in annoyance responses. In terms of explanations for the increase in annoyance response, it cannot be ruled out that methodological differences in the HA assessment may be the reason for changes in annoyance over the years.

3.15 The results of the DEBATS study also highlight the relevance of a number of non-acoustical factors in relation to aircraft noise annoyance, and the need to take them into account in the prediction models. The results highlighted in this first survey have yet to be confirmed by the upcoming longitudinal analysis of the annoyance responses to noise based on the data collected in the DEBATS three-wave survey carried out first in 2013, then in 2015 and finally in 2017.

3.16 **Soeta and Kagawa** authored a paper that described a study into a three-dimensional psychological evaluation of aircraft noise and prediction by physical parameters. Aircraft noise was measured at two locations under take-off and landing routes near Osaka International Airport. Sixteen stimuli with a mean noise level of < 80 dB L_{Aeq} were selected from the measured aircraft noise, (six from the take-off route and ten from the landing route).

3.17 38 participants aged between 20 and 34 were selected to be part of the overall study, with 12 in the annoyance experiment, 13 in the loudness experiment and 13 in the pitch experiment. The aircraft noises were analysed to evaluate which factors significantly influence subjective perception of annoyance, loudness and pitch of these elements of the noise.

3.18 The results indicated that sound level and temporal variation of the sound level, and spectral centroid[2] both influenced subjective annoyance. Sound level and spectral content also significantly influenced subjective loudness. Temporal variation and spectral centroid significantly influenced subjective pitch.

3.19 The authors suggest that this type of study could be used for a wider range of noise sources such as road traffic and railway noise with the aim of providing information for environmental standards for acoustic environments.

[2] The spectral centroid is a measure used in digital signal processing to characterise a spectrum. It indicates where the centre of mass of the spectrum is located. Perceptually, it has a robust connection with the impression of brightness of a sound.

Birth Outcomes

3.20 **Argys et al** published a paper on residential noise exposure and health, and the evidence from aviation noise sources relating to birth outcomes. Previous studies have found an association between noise exposure and low birth rates, there is a lack of estimates of the effect of this outcome. The authors explain that there is a relationship between birth weight and factors such as health, education and earnings in adulthood. This American study focussed on the effects of aircraft noise on babies' health at birth, specifically low birthweight (defined as birthweight under 2,500g) born to mothers living near Newark Liberty International Airport.

3.21 The design of the study utilised an unintentional increase in aircraft noise exposure due to the Federal Aviation Administration's (FAA) initiative started in 2006, named the Next Generation Air Transportation System (known as NextGen), which was aimed at improving air travel, reducing delays and saving fuel. One feature of NextGen is the use of precision satellite monitoring (replacing radar-based surveillance), which produces satellite designed optimum routes that reduce flight time and save fuel. However, usage of these optimum routes by more and more aircraft, combined with landing at lower altitudes (resulting from precision satellite monitoring), has exposed residents living in an area under the new routes to increased aircraft noise and "a constant barrage of airplanes flying over their homes" (CBS News, 2015). The resulting variation in noise exposure was exploited by the authors in order to examine the relationship between aircraft noise and birth outcomes in babies born in New Jersey between 2004 and 2016 (data obtained from the New Jersey Department of Health).

3.22 The data allowed the authors to pinpoint those mothers living close to the airport and in which direction relative to the runway their dwelling was, also where there was a NextGen-induced increase in noise exposure. Other data included birth weight (measured in grams), gestational length (measured in weeks), the sex of the baby, and the characteristics of the mother including her age, race and ethnicity, education, marital status, number of prenatal visits, and smoking status.

3.23 Suggested mechanisms for an effect of noise on birth outcomes include noise-induced hormonal activation, sleep disturbance and stress which may affect gestation. It is also possible that the body's central response to stress results in disrupted sleep, increased heart rate, cortisol release, and increase in blood pressure. Importantly, this occurs regardless of whether the person is annoyed by the noise, and this effect does not habituate. It is explained that pregnant women are particularly vulnerable to noise because of the increased central stress function during pregnancy and the resulting release of stress hormones that can have negative effects on foetal health.

3.24 The study looked at the relationship between birth outcomes and aircraft noise exposure above 55 dB L_{Aeq}. The study duration (2004-2016) was split into two time scales based on the introduction of NextGen at the airport. The pre-period was classed as 2004-2010, and the post period was 2011-2016. The authors explain that the component of NextGen that is most related to the precision satellite monitoring of aircraft (e.g. the use of satellite-designed optimum routes and gradual descent) is the Performance Based Navigation (PBN) component, which was obtained around 2009-2010. The 2011-2016 period was therefore classed as the period that NextGen could have had the most impact on those people living near the airport and in the direction of the runway.

3.25 The results indicated an increase of 1.6% points in the probability of having low birth weight babies from mothers who were living close to the airport, in the direction of the runway and who experienced >55 dB LAeq and in the period 2011-2016. There was also an effect on gender of the baby, with low birth weight being more prominent among male babies than females.

3.26 The authors explain that these findings align with those from Zafari et al (2018), who weighs up the benefits of NextGen's flight path optimisation (increased fuel efficiency and reduced flight time) against the unintended adverse effects on health as measured by reduced quality-adjusted life years (QALYs).

Mental health

3.27 **Beutel et al** conducted a study that examined whether the effects of noise annoyance could be associated with depression, anxiety and sleep disturbance five years later. The study aimed to investigate any long-term effects of noise and associated annoyance, on mental health.

3.28 The authors investigated longitudinal data of over 11,900 participants of the Gutenberg Health Study, a population-based, prospective, single-centre cohort study in mid-Germany (age at baseline 35–74 years). Noise annoyance from aircraft, road traffic, railway noise, industrial noise and neighbourhood noise was assessed at baseline and again during a 5-year follow-up study. Annoyance was measured during the day and at night in each stage of the study. Depression, anxiety and sleep disturbance were assessed using the Patient Health Questionnaire and Generalised Anxiety Disorder Questionnaire.

3.29 Figure 3 displays the annoyance results, which indicated that overall noise annoyance remained stable over the 5-year period. There was a significant decrease in noise annoyance relating to aircraft over the 5 years, although aircraft noise annoyance was the most annoying source for day and night at each stage of the study. During the day, road traffic annoyance was the second most annoying source of noise, followed by neighbourhood, industrial and

railway noise. At night, neighbourhood exceeded road traffic and railway noise exceeded industrial noise annoyance. General noise annoyance remained stable throughout the study.

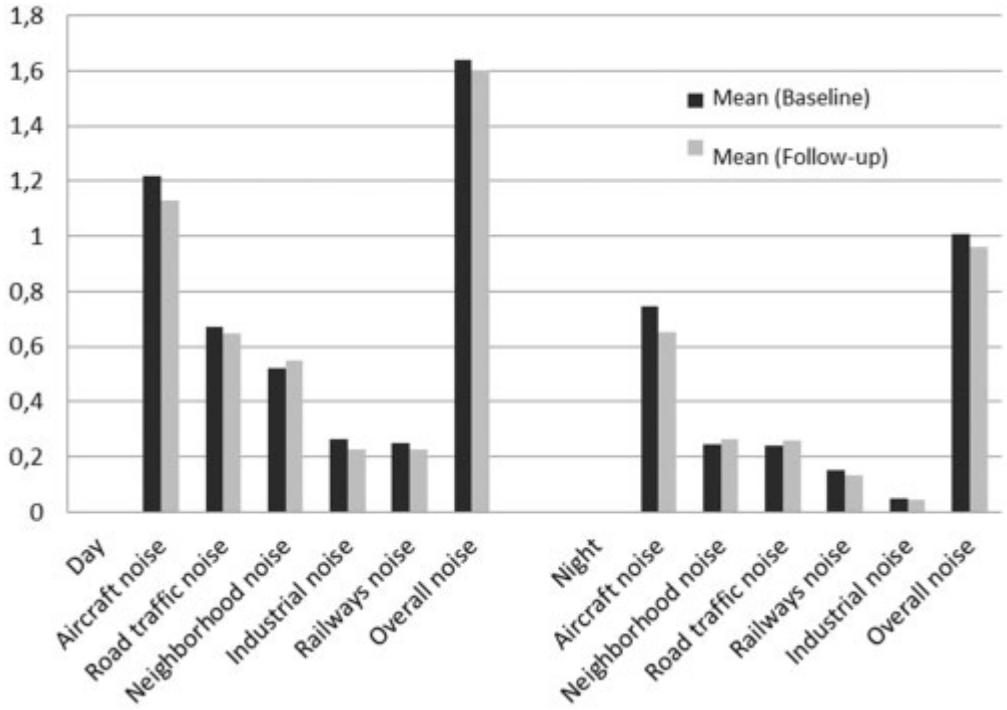

Figure 3: Mean noise annoyance by different sources at daytime and night time at baseline and follow-up.

3.30 The mental health results indicated that daytime noise annoyance predicted new onset of depressive, anxiety symptoms (also night-time annoyance) and sleep disturbance (beyond respective baseline scores). Additional predictors for this finding were being female, having a lower age and being of low socioeconomic status (SES). Night shift work was also associated with depression. Overall, baseline annoyance remained predictive of follow-up distress and sleep disturbances, even when follow-up annoyance was included in the regression model. Thus, long-term effects of annoyance on major mental health variables persisted. This applied to aircraft, neighbourhood and industrial noise annoyance. Noise annoyance baseline scores from specific sources (aircraft, neighbourhood, industrial) remained significant predictors of depression and anxiety, in addition to annoyance at follow-up.

3.31 The source-specific results indicated that daytime baseline aircraft annoyance predicted depression and anxiety. Sleep disturbance was most consistently predicted by neighbourhood annoyance (baseline and follow-up) and follow-up annoyance by aircraft (night) and road traffic (day and night).

Sleep disturbance

3.32 **Thiesse et al** published a study into how transportation noise impairs cardiovascular function without altering sleep, highlighting the importance of autonomic arousals. Although this is not an aircraft noise-specific study, the noise sources of road traffic and railway noise are often studied alongside aviation noise, as they are all potential sources of disturbance to sleep.

3.33 This study examined whether continued exposure to transportation noise at night impacts the main stress pathways and whether this in turn leads to changes in sleep architecture. This laboratory study involved 26 healthy young participants spending five full 24-hour days in the study environment with a baseline and recovery night, plus four different noise scenarios (low/medium/high intermittent road or rail scenarios with an identical equivalent continuous sound level of 45 dB) randomly presented during the nights. The participants had their sleep measured by polysomnography[3] in order to examine sleep structure and changes throughout the study.

3.34 The results indicated that participants were more annoyed from the exposure to transportation noise compared to baseline, but the night-time noise did not result in significant changes to sleep architecture, blood pressure, and some hormone levels. There was an increase in evening cortisol levels after sleeping with highly intermittent road noise levels compared to the baseline night ($p < 0.005$), which the authors found to be due to increasing length of autonomic arousals during the noise exposure nights.

3.35 The authors concluded that nocturnal transportation noise of 45 dB L_{Aeq} and above is a physiological stressor that affects the hypothalamic-pituitary-adrenal axis[4] during the following day in healthy young sleepers.

[3] A polysomnogram (PSG) is a procedure that utilises electroencephalogram, electro-oculogram, electromyogram, electrocardiogram, and pulse oximetry, as well as airflow and respiratory effort, to evaluate for underlying causes of sleep disturbances.

[4] The hypothalamic pituitary adrenal (HPA) axis is the central stress response system. HPA axis describes the interaction between the hypothalamus, pituitary gland, and adrenal glands.

Chapter 4

ICCAN Review

4.1 In September 2020 the Independent Commission on Civil Aviation Noise published their review on Aviation Noise and Public Health. The report was produced by NatCen, a social research company. The aim of the report was to "*collate and summarise the scientific evidence on the links between aviation noise and health, to identify evidence gaps and to suggest ways that further research could fill these gaps".*

4.2 The review was conducted as a Rapid Evidence Assessment (REA), a method used to identify and process available findings within a specific timeframe. ICCAN state that they hope to use the evidence from the REA to achieve the following:

- Identify new evidence that links aviation noise to health outcomes
- Identify evidence gaps in research that links aviation noise to health
- Put forward research methodologies that might be feasible to fill identified evidence gaps

4.3 The basis for the review was the WHO's systematic reviews on environmental noise and:

- Adverse Birth Outcomes
- Cognition
- Cardiovascular and Metabolic Effects
- Sleep
- Quality of life, wellbeing and mental health

4.4 Annoyance was deemed to be out of the scope of the review. Defra's two 2019 published reviews with RIVM (annoyance, sleep disturbance, cardiovascular and metabolic health outcomes) and Arup (mental health, wellbeing, quality of life, cancer, dementia, other neurodegenerative outcomes and birth, reproductive and cognitive health outcomes) were also used as a starting point for the review.

4.5 The eligibility criteria for inclusion in the ICCAN review was similar to that for the WHO and Defra reviews. The paper describes the review process and explains that of the 1,494 results originally found in the search, following screening 12 were included in the review. These addressed the following areas:

- Sleep (4 papers)

- Quality of life, mental health and wellbeing (2 papers)
- Cardiovascular and metabolic disorders (8 papers)

4.6 The review includes summaries of these studies, which were also reported in the last of these three CAP health effect update reports in 2019 and 2020 (CAPs 1713, 1841 and 1883). The GRADE system was then applied to the evidence from the new research and the WHO and Defra reviews, and assigned a rating of 'high', 'moderate', 'low' or 'very low'. The ratings for each of the possible health outcomes are presented in tabular form in the report.

4.7 The review discusses the gaps in the research and the ratings for each health outcome. For most health outcomes, the evidence on the effects of aviation noise is low or very low quality. The review explains that such low quality is primarily driven by the fact that most studies use a cross-sectional design, and many have small sample sizes which limits their power.

4.8 For a small number of outcomes, in the areas of sleep and cognition, there is moderate quality evidence on the links between aviation noise and public health. Typically, it is difficult to achieve high quality evidence in environmental studies, and moderate quality evidence is therefore considered sufficiently robust to support strong policy recommendations. Table 2, taken from the ICCAN report, highlights the outcomes that are deemed to have moderate quality evidence and therefore these are not an immediate priority for future research.

Table 2: Outcomes for which there is moderate quality evidence from WHO, Defra and ICCAN reviews

Outcome	Direction of effect
Stroke mortality	No effect
Stroke incidence	Harmful effect
Self-reported sleep disturbance in adults (source specified)	Harmful effect
Physiologically measured awakenings in adults	Harmful effect
Change in waist circumference	Harmful effect
Reading comprehension	Harmful effect
Impairment assessed through SATs	Harmful effect
Short-term and long-term (episodic) memory	Harmful effect

4.9 The review suggests that for health outcomes such as these with moderate quality evidence, there is a need to quantify how interventions or operational changes impact health outcomes.

4.10 For some areas of health, including dementia and other neurodegenerative outcomes, cancer, and birth and reproductive outcomes, there is little or no evidence at all relating to aviation noise. The review therefore suggests that these outcomes are candidates for future research.

4.11 Diabetes and hypertension are also considerable diseases that can lead to morbidity, for which the evidence is currently only of low or very low quality. There is also very low quality evidence on birth and reproductive outcomes. The authors suggest that the potential contribution of aviation noise exposure, via maternal stress responses, to outcomes such as low birth weight or prematurity may be minimal compared to other exposures (as is true for many cardiovascular and metabolic outcomes). The importance of studying birth-related outcomes is increased by the long-term morbidity that they can cause, and they could be considered as an area for further research.

4.12 The authors draw attention to the fact that neither the ICCAN update review nor the systematic reviews for WHO and Defra include any evidence relating to auto-immune disorders, which represent an area of future research.

4.13 In terms of the UK, the review concludes that there has been relatively little research data here, and this is despite having a large noise-exposed population and Europe's busiest airport. The two current large research projects (ANCO and RISTANCO) will be important additions to the UK dataset.

4.14 Priority areas for Public Health England in the next five years which may have aircraft noise as a relevant exposure or co-exposure include air pollution, mental health, childhood obesity and health inequalities resulting from poverty, air pollution or social stressors. All these areas present opportunities for exploration.

4.15 The review presents possible methodologies for filling the evidence gaps identified. These include retrospective cohort methods using UK cohort data, which would obtain data in a cost-effective relatively quick way. This would include evidence relating to chronic disease outcomes as well as birth and reproductive outcomes. It is suggested that where cohorts cannot be used for such purposes, retrospective ecological studies using routine health datasets could be considered as an alternative.

Chapter 5

Summary

This report has provided a summary of some of the main findings in the past six months (March 2020 to September 2020) with regards to aircraft noise and health effects. It has included relevant findings from the Internoise Congress, a summary of the recently-published review published by ICCAN, and other published and peer-reviewed research from academic journals.

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.

Chapter 6

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