

Aircraft Noise and Health Effects – a six monthly update

CAP 1883



Published by the Civil Aviation Authority, 2020

Civil Aviation Authority
Aviation House
Beehive Ring Road
Crawley
West Sussex
RH6 0YR

You can copy and use this text but please ensure you always use the most up to date version and use it in context so as not to be misleading, and credit the CAA.

Enquiries regarding the content of this publication should be addressed to: noise@caa.co.uk

The latest version of this document is available in electronic format at: www.caa.co.uk/CAP1883

Contents

Contents	3
Chapter 1	4
Introduction	4
Chapter 2	5
International Congress on Acoustics (ICA) Findings	5
Measuring Annoyance	5
Cardiovascular Disease	12
Sleep Disturbance	14
Implications of the 2018 WHO Noise Guidelines	16
Children's Health	21
Chapter 3	24
Defra commissioned reviews	24
Chapter 4	30
Summary	30
Chapter 5	31
References	31

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 2019 to March 2020 and includes relevant findings presented at the International Congress on Acoustics (ICA), held in Aachen in September 2019. The report also discusses recent publications from the Department of Environment, Food and Rural Affairs (Defra) on environmental noise and health outcomes.
- 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

International Congress on Acoustics (ICA) Findings

- 2.1 The ICA Congress was held in September 2019 in Aachen, Germany. The relevant findings relating to aircraft noise and health outcomes are presented in this chapter according to subject area.

Measuring Annoyance

- 2.2 The first paper is authored by **Quehl et al** from Germany, who examined the effects of nocturnal aircraft noise on short-term annoyance in children, and the influence of non-acoustic and acoustic factors. Children are considered a vulnerable group in terms of the potential impact of environmental noise due to their sensitive developmental stage and because of the lack of established coping mechanisms compared to adults. The effect of nocturnal aircraft noise on children has not been widely studied, and this field study examined 51 children aged 8-10 years old living around Cologne/Bonn airport.
- 2.3 The study occurred over four consecutive nights, with aircraft noise measurements taken inside the bedrooms. The number of aircraft movements was also considered. Short-term annoyance was measured the following morning, 30 minutes after waking, via a question recommended by the International Commission on the Biological Effects of Noise (ICBEN). The children were also interviewed on the first day and any moderating psychological factors relating to noise and annoyance were found. Questions to establish noise sensitivity, perceptions of air traffic and attitudes towards aircraft use were also asked within the initial questionnaire.
- 2.4 The results were analysed using logistic regression, and a model for short-term annoyance was established. Only those factors that showed an increased trend effect for annoyance were included in the model, until no further improvement in the model could be obtained. None of the noise metrics, including number of aircraft movements had any effect on short-term annoyance ($p \geq 0.6$) and the odds ratios of all noise metrics were close to 1, meaning that there was no effect of noise exposure on annoyance response.
- 2.5 When non-acoustic parameters were included, such as noise sensitivity, attitudes towards air traffic, e.g. 'aircrafts are dangerous', and coping behaviour in the presence of aircraft noise, the model improved to the best fit for predicting short-term annoyance due to nocturnal aircraft noise. The results from this study are quite surprising as the level of night-time aircraft noise and number of movements were not related to short-term annoyance in children, as would be

expected in adults. However, when combined with non-acoustic factors such as sensitivity and attitudes towards aircraft, the effect was significant.

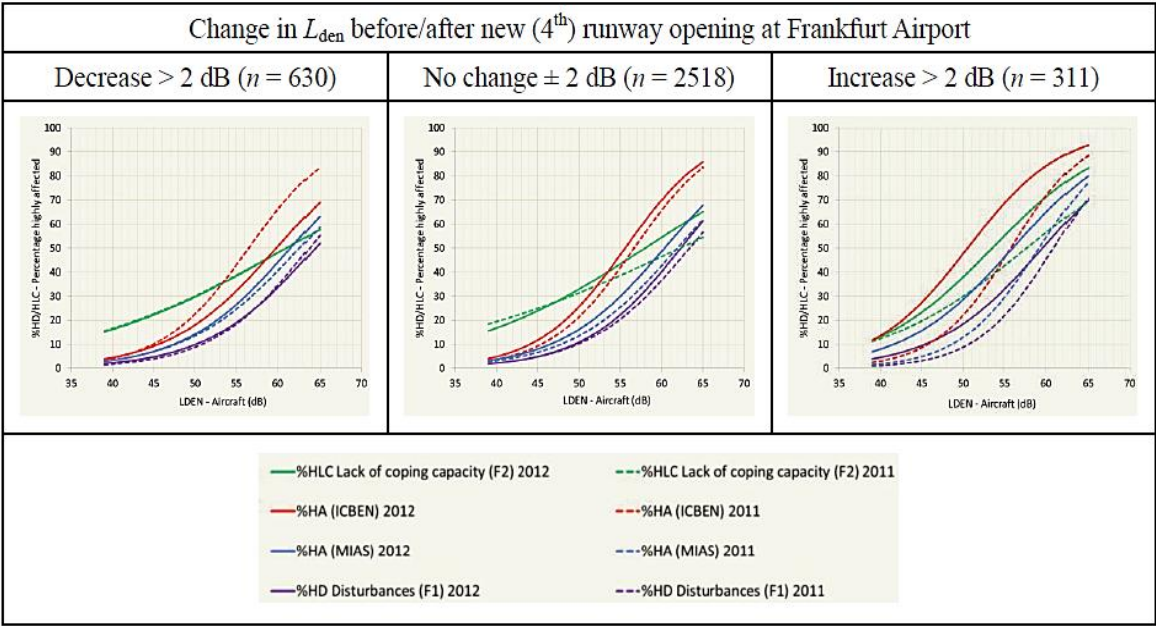
- 2.6 **Marki et al** presented the outcomes from their work on using a mobile application to assess quality of the acoustic and visual environment, and the relationship with aircraft noise.
- 2.7 The basis for this work is underpinned by the importance of non-acoustic factors in relation to the perception of sound environments. The study was conducted under the Aviation Noise Impact Management through Novel Approaches (ANIMA) European project on the impact of aviation noise. It used an Experience Sampling method to assess people's perception of quality in their acoustic and visual environments around airports in real time rather than retrospectively as is usually the case with annoyance studies. The study is one of several pilot studies being conducted as part of ANIMA.
- 2.8 The advantages of using smartphones as a means of recruitment and data collection include: greatly reduced cost compared to traditional methods; convenience of recruitment using social media; high quality pictures and sound recordings can be taken; location can be accurately measured; and an instant two-way data flow is possible between the participant and the researchers.
- 2.9 For this study a dedicated mobile application was developed, and participants were notified 1-3 times each day for the duration of the study, with randomised data obtained for every hour during the day (07:00-23:00, weekdays; 08:00-22:00, weekends). When alerted, a snapshot of the acoustic environment was recorded, along with the location, a short questionnaire on perception of the surroundings, and a picture taken of the surroundings. The duration of the study was for two or three weeks. End of week and weekend questionnaires were also completed, and a larger questionnaire on noise sensitivity and well-being was completed at the end of the study. For this study, the app was tested on a small number of participants that were selected by the researchers, with the aim of obtaining feedback on the design and functionality of the app. This version of the app was the pre-release version, and the pilot study revealed that participants found the app easy to use but slightly too long. They suggested that the frequency of measurements could be increased to up to five times per day, which would decrease the overall length of the study. Photos will not be taken and stored in the release version, and instead the type of landscape will be assessed. The authors intended to begin another pilot study with the release version at the end of 2019. The release stage consists of:
- Refinement of the test method
 - Modification of the app and release in the Apple App Store and Google Play Store

- Recruitment of 60 participants around two airports (London Heathrow and Ljubljana, Slovenia) for the post-release pilot study
- Evaluation of the performance of the study
- Evaluation of the data collected

- 2.10 **Schreckenberg et al** authored a paper on the assessment of the impact of changes in noise exposure at an expanding airport by means of the Multiple Item Annoyance Scale (MIAS).
- 2.11 The purpose of the MIAS is to incorporate the different dimensions to the annoyance response. These include the experience of an often-repeated noise-related disturbance and the behavioural response to it; the emotional response to the sound and its disturbing impact; and the perception of control of the noise situation.
- 2.12 The advantages of using a MIAS include:
- It helps to understand the interrelations between different noise effects and therefore might be more effective in the assessment of the impact of noise-related interventions.
 - Using multiple items to assess annoyance means response bias is reduced and different causes of different components of annoyance are more explicit.
- 2.13 MIAS includes seven items, including the 5-point ICBEN annoyance scale and the sub-dimensions 'noise disturbances' and 'lack of coping capacity', which each consist of three items.
- 2.14 In this study, the aim was to investigate changes in the sub-dimensions for aircraft noise annoyance before and after a new runway was opened at Frankfurt Airport, and the introduction of a new night noise curfew for residential areas around the airport. Longitudinal survey data from the NORAH (Noise-related annoyance, cognition and health) study was used before (2011) and after (2012) the opening of the fourth runway at Frankfurt Airport. The night flight curfew also occurred in 2011.
- 2.15 Over 3,500 participants took part in the study, living within the daytime 40 dB $L_{Aeq,16h}$ (06:00-22:00) and night time $L_{Aeq,8h}$ (22:00-06:00) noise contours. They completed telephone interviews and were also given the option of completing an online survey. The MIAS comprises two Factors, the first being 'Disturbances due to aircraft noise' (F1) which include the standard ICBEN 5-point scale annoyance question, together with other forms of disturbance related to aircraft noise such as disturbance of activities (watching TV, listening to the radio, talking etc). The second Factor is 'Lack of coping capacity' (F2), which includes three items asking participants to judge statements referring to their perceived ability to protect themselves against noise, close windows, or whether they felt helpless

towards the noise. The components of F1, F2 and the 5-point annoyance score are combined using weights for the contributing items, to form a MIAS score.

2.16 Figure 1 shows the exposure-response relationships before and after changes in aircraft noise at Frankfurt airport. The percentage of people Highly Annoyed (%HA), Highly Disturbed (%HD), and perceiving a high lack of coping capacity (%HLC) are shown. Response scores above the 72% cut-off were classed as HA, HD and HLC.



Note. Blue/red curves: percentage (%) highly annoyed as assessed with MIAS (blue) and ICBEN item (red); violet: % highly disturbed; green: % perceiving high lack of control; dashed: assessments of 2011; solid: assessments of 2012. For better readability, limits of the 95% confidence intervals are not shown. All responses refer to aircraft noise.

Figure 1: Summary of exposure-response relationships for MIAS and its components against L_{den} in groups of changes in aircraft noise in 2012 after the opening of the new runway. Reproduced without permission from ICA proceedings.

- 2.17 The results indicate a change effect i.e. a shift in %HA in 2012 compared to 2011, particularly for those participants experiencing an increase of >2 dB L_{den} . The change effect observed is greater for annoyance assessed with the single ICBEN 5-point scale compared to assessment with the MIAS score. The MIAS score suggests little evidence for a change effect, particularly in the ‘disturbances’ element. In those areas of no change or an increase in aircraft noise exposure, a change effect was observed in the ‘lack of coping capacity’ factor, which increases as the noise exposure increases.
- 2.18 Previously, when the NORAH data has been analysed elsewhere, the results have indicated that in the condition that aircraft noise increases by >2 dB L_{den} , the sound level alone is not purely responsible for the increase in annoyance

values. In this instance, it was found that annoyance changes were predicted by coping ability, and attitudes and expectations regarding air traffic.

- 2.19 There is also evidence in this study that trust in authorities is a further consideration when investigating annoyance responses to aircraft noise. The authors suggest that when aircraft noise exposure increases, this threatens the perceived control and trust in others thought to be responsible for improving/not worsening the residential situation, which in turn also impacts the well-being of individuals.
- 2.20 **Flindell and Hooper** authored a paper on the meaning of noise annoyance, which discussed the issues surrounding the meaning of annoyance and subsequent assessment. The paper discusses the historical issues regarding the definition of annoyance and the subsequent development of the two ICBEN 5- and 11-point scales in 2001 for use separately or together within noise annoyance questionnaires. The development of these scales allowed for increased standardisation across studies, and because they were created in nine different languages, across countries also.
- 2.21 The authors discuss the possibility that in their recent experience, the supposed degree of benefit from using the scales may not have been achieved. They cite the differences in Guski's meta-analysis (Figure 2) illustrating the different dose-response relationships between aircraft noise and annoyance in various studies since 2001.

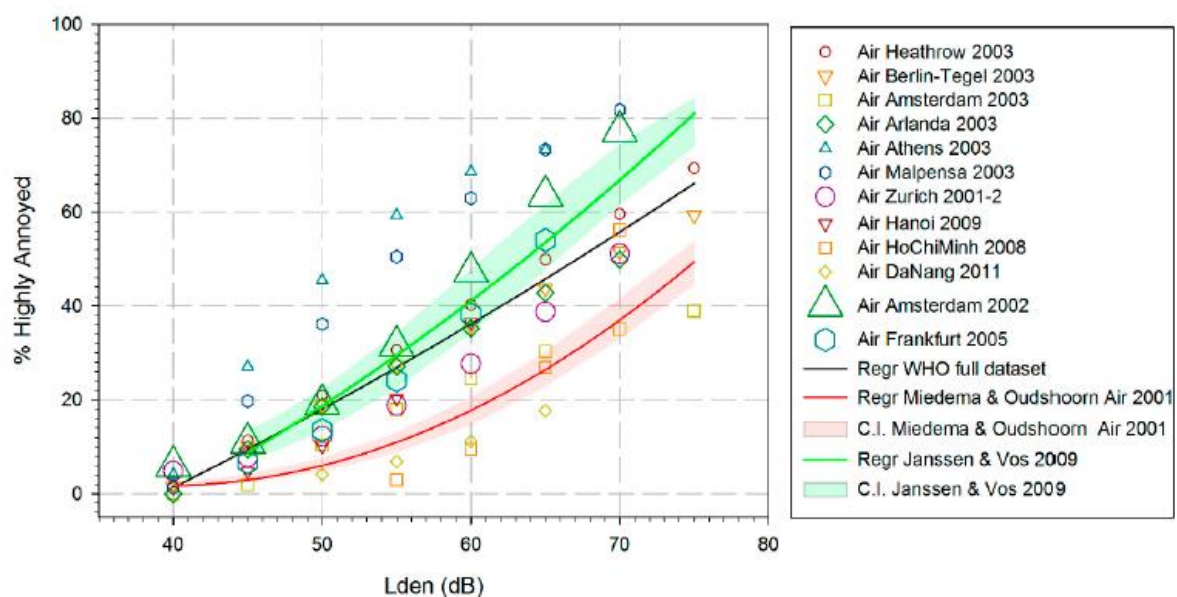


Figure 2: Scatterplot of the annoyance response data from 12 studies included in the WHO dataset, used to develop the updated WHO Noise Guidelines for Europe in 2018. Exposure-response relationships are also included from Miedema and

Oudshoorn and Janssen and Vos. The size of the data points corresponds to the number of participants.

- 2.22 Flindell and Hooper offer possible reasons for the variations found in the annoyance studies, such as the populations selected at given times and locations exhibit fundamentally different responses; differences in acoustic factors that may be present when conducting surveys at different times and in different places; and the possibility that although standardised, the ICBEN questions may in fact be measuring different responses in different circumstances.
- 2.23 The paper goes on to offer a more detailed explanation of the various reasons for finding differing annoyance responses in relation to aircraft noise and discusses the effect of individual differences and the transactional model of stress and coping (by Lazarus, Figure 3). Studies based on this model identify certain pre-cursors, implications and consequences of noise annoyance models and integrate them into a single coherent model.

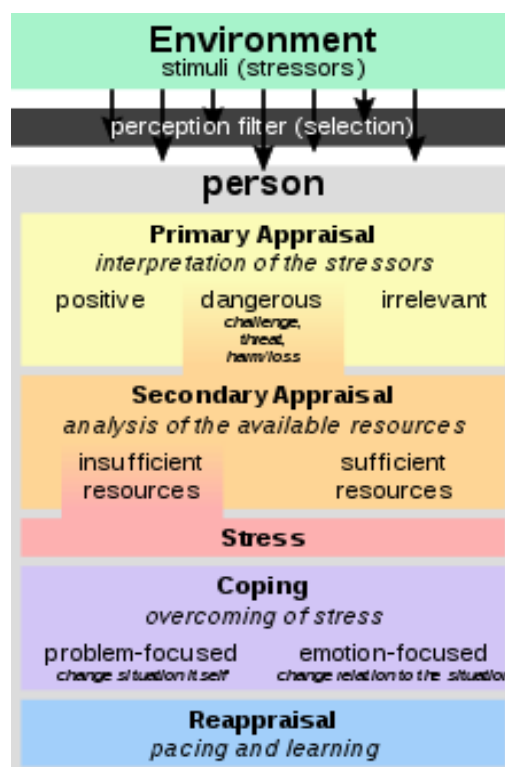


Figure 3: Transactional stress model (Lazarus and Folkman)

- 2.24 The authors explain this model in detail; briefly, that stress is the result of an interaction between environmental and personal factors. The subjective evaluation of the stressor and the person's available resources is an important factor. The model suggests that when the primary appraisal of the situation occurs (interpretation of the stressor) the person will either assess it as posi