

Aircraft noise, sleep disturbance and health effects

CAP 1164



Documents

Document Sharing Hub

© Civil Aviation Authority 2014

All rights reserved. Copies of this publication may be reproduced for personal use, or for use within a company or organisation, but may not otherwise be reproduced for publication.

To use or reference CAA publications for any other purpose, for example within training material for students, please contact the CAA at the address below for formal agreement.

The work reported herein was carried out under a Letter of Agreement placed on 4 April 2013 by the Department for Transport. Any views expressed are not necessarily those of the Secretary of State for Transport.

Enquiries regarding the content of this publication should be addressed to:
Environmental Research and Consultancy Department, Policy Programmes Team,
Civil Aviation Authority, CAA House, 45-59 Kingsway, London, WC2B 6TE.

The latest version of this document is available in electronic format at www.caa.co.uk/publications, where you may also register for e-mail notification of amendments.

Contents

Executive summary	4
Chapter 1 Background	5
Chapter 2 Recent UK studies	6
Hansell et al	6
Floud et al	10
Chapter 3 European research	13
Management, structure and work packages	14
Results of Work Package 3 – Noise exposure assessment	15
Results of Work Package 6 – New strategies for noise and health research in Europe	16
Babisch meta-analysis	19
Internoise 2013	22
Chapter 4 USA research	25
PARTNER work	28
Chapter 5 Conclusions	32
Chapter 6 References	33

Executive summary

This report is an update to ERCD Report 1208, and serves to provide an overview of recent developments since the publication of 1208 in January 2013 in the research field of aircraft noise, sleep disturbance and health effects. This report was commissioned by the Department for Transport to provide an up-to-date account of current knowledge in this area.

CHAPTER 1**Background**

- 1.1 This report was commissioned by the Department for Transport and provides an update to the literature review (ERCD 1208) published in early 2013. That report summarised the main health effects associated with night-time aircraft noise, and suggested a potential method for monetising the impact of night flights in the UK. In conjunction with ERCD 1208, a second report was also published (ERCD 1209), that proposed a methodology for estimating the cost of sleep disturbance from aircraft noise. This update does not affect the recommendations offered in that report.
- 1.2 This paper was commissioned to take account of, and review several recent reports that have been published in the environmental noise and health effects area since ERCD Report 1208 was published. Two of these publications use data around Heathrow airport to investigate cardiovascular impacts of aircraft noise. European work has included the final report from the European Network of Noise and Health (ENNAH), which is the largest network of noise and health researchers to date and includes recommended directions for future research, and identified current knowledge gaps. In addition, Babisch from the Federal Environment Agency in Germany has published a meta-analysis of noise and exposure response curves for transportation noise and cardiovascular diseases. Further afield, a Harvard study attempts to examine the cardiovascular impacts around 89 airports within the USA and the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) literature review on the potential health effects of aircraft noise is also referred to within this update as this work was previously omitted from ERCD 1208.
- 1.3 It should be noted that although these publications are not night-time specific, they are potentially relevant to night time effects of aircraft noise and have therefore been included as a more general update to the original literature review.

CHAPTER 2

Recent UK studies

- 2.1 The findings from two studies focused around Heathrow airport were published in late 2013, and attracted considerable media attention due to the possible aircraft-noise induced health impacts on UK residents living in this vicinity that were identified.

Hansell et al

- 2.2 The first was by Hansell et al (2013) from Imperial College, London which had the aim of investigating the association between aircraft noise and the risk of stroke, coronary heart disease and cardiovascular disease. The background to the research was that although there have been studies investigating cardiovascular effects of aircraft noise, the outcomes of those looking at stroke, coronary heart disease or cardiovascular disease are inconsistent. A possible reason for this may be due to a lack of statistical power because of the relatively small numbers of people exposed to high levels of aircraft noise.
- 2.3 This study examined comparisons between hospital admission rates for cardiovascular disease and mortality in neighbourhoods exposed to aircraft noise from Heathrow airport. Daytime (0700-2300) and night time (2300-0700) noise exposures were expressed as the average annual day $LA_{eq, 16h}$ and annual night $LA_{eq, 8h}$ respectively at a spatial resolution of 100 x 100 m, as estimated each year by the UK CAA and published by the Department for Transport. The study area included twelve London boroughs and nine districts to the west of London exposed to noise levels of at least 50 dBA daytime ($LA_{eq, 16h}$). For the twelve London boroughs data on air pollution in the form of particulate matter (PM_{10}) at 20 x 20 m resolution, and road traffic noise at a spatial resolution of 10 x 10 m ($LA_{eq, 16h}$) were also examined as potential confounding variables. Neighbourhoods were defined using the national census geographical units. The data on hospital admissions and deaths for 2001-2005 were obtained from the Office for National Statistics and Department of Health. The data for stroke, coronary heart disease and cardiovascular disease were then linked to postcode, geographic location and then noise exposure level. Confounders such as ethnicity, lung cancer (as a proxy for smoking) and deprivation were included.
- 2.4 Daytime aircraft noise and road noise was grouped into six categories from ≥ 51 to >63 dB in increments of 3 dB. For night time aircraft noise the increments were set at 5 dB intervals as less people were affected and categorised as ≤ 50 , >50 , and >55 dB. In order for a comparison between day and night time data to be made, daytime aircraft noise was also analysed using the same 5 dB groups. The study area covered 3.6 million people, only 2% living in the highest category of daytime or night time noise exposure.

2.5 The main findings on the hospital admissions with regard to stroke, coronary heart disease and cardiovascular disease are shown in Figure 1. With increased aircraft noise the risk of hospital admission also increased, with adjustment for ethnicity, deprivation and smoking included.

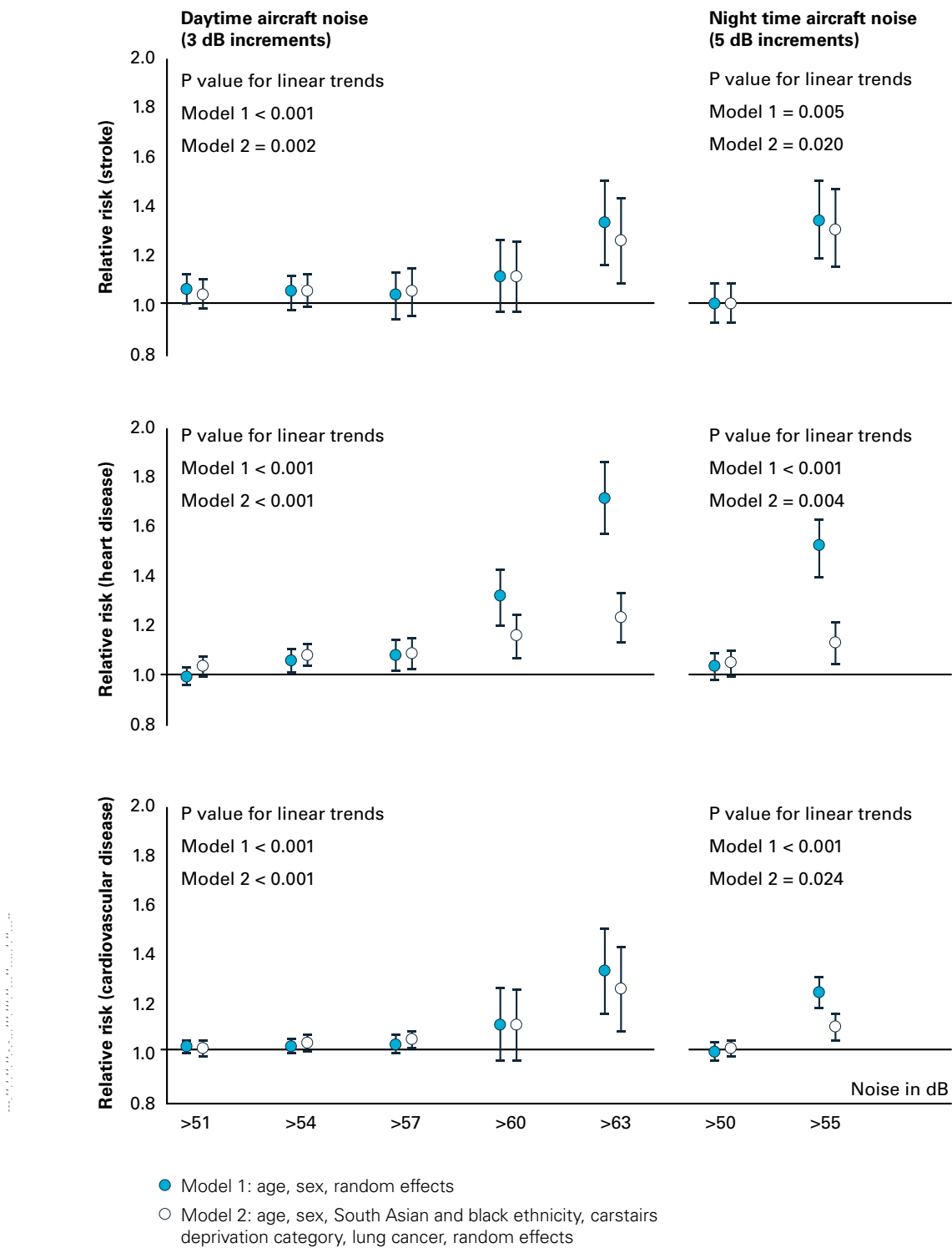


Figure 1: Relative risks for associations between hospital admissions for stroke coronary heart disease and cardiovascular disease between 2001 and 2005, and the annual weighted average daytime aircraft noise and night time aircraft noise in 2001 census output areas. Reproduced without permission from Hansell et al (2013).

- 2.6 The two sets of data illustrate the difference between the two types of adjustment for confounders. Model one represents adjustment for age, sex and random effects, and model two also includes ethnicity, deprivation and lung cancer. This separate analysis was chosen because the initial data highlighted that areas with a high proportion of South Asian and black ethnicity population were concentrated in the north eastern and eastern parts of the study area, which were also areas with higher deprivation and lung cancer risk.
- 2.7 Interestingly, adjustment for ethnicity, deprivation and lung cancer results in a much lesser degree of relative risk of hospital admissions particularly for coronary heart disease at noise exposure levels of more than 60 dB LA_{eq}, 16_h. The same pattern is seen for cardiovascular disease, although to a lesser degree. It is important to consider the effect of ethnicity (in particular South Asian ethnicity, which is itself strongly associated with risk of coronary heart disease). The authors explained that when controlling for South Asian ethnicity in particular. It has a noticeable effect on these results, the effect due to noise exposure decreases quite dramatically. When comparing areas exposed to more than 63 dB LA_{eq}, 16_h to those exposed to 51 dB LA_{eq}, 16_h or less, the relative risk for hospital admissions due to stroke was 1.24 (1.08 to 1.43, 95% CI), for coronary heart disease was 1.21 (1.12 to 1.31, 95% CI) and for cardiovascular disease was 1.14 (1.08 to 1.20, 95% CI). The results for night time aircraft noise (>55 dB v ≤50 dB) were 1.29 (1.14 to 1.46, 95% CI), 1.12 (1.04 to 1.20, 95% CI) and 1.09 (1.04 to 1.14, 95% CI) respectively. When using the same categories for daytime and night time noise the results suggested higher relative risks for night time noise.
- 2.8 The corresponding results for relative risk of mortality were similar at the higher noise levels. In adjusted models for daytime aircraft noise (>63 dB v ≤51 dB) the relative risk for stroke mortality was 1.21 (95% confidence interval 0.98 to 1.49), for coronary heart disease was 1.15 (1.02 to 1.30), and for cardiovascular disease was 1.16 (1.04 to 1.29). The relative risks for night time aircraft noise (>55 dB v ≤50 dB) were 1.23 (1.02 to 1.26), 1.11 (0.99 to 1.24), and 1.14 (1.03 to 1.26) respectively. The results were unchanged with additional adjustment for PM₁₀ and road traffic noise in the twelve boroughs of London. It was reported that the results obtained when using the same categories for daytime and night time aircraft noise indicated that the relative risks for mortality were higher for night time noise.
- 2.9 There are several issues to consider when interpreting the results from this study. Firstly, although road noise was included in the confounding variable analysis, rail noise was omitted which would have helped give a more representative group of noise confounders. Secondly, although the researchers have attempted to take into account the issue of confounding air pollution by including exposure to PM₁₀, they did not include exposure to Nitrogen Dioxides (NO₂), possibly because NO₂ is primarily linked with respiratory disease rather than cardiovascular disease. However, considering that NO₂ concentrations

exceed EU Air Quality limits at a number of locations within the study area - including both factors would have enabled any confounding effects of air pollution to be more fully understood.

- 2.10 In terms of the noise categories, the increments ceased at 63 dB and above. It is unclear why this number was chosen as the cut-off point and levels such as 66 dB and 69 dB and above were all grouped together in this category and not analysed separately, even though there should have been sufficient population numbers in order to perform discrete analyses. It is possible, however, that this choice was due to statistical sampling issues, whereby there were not enough hospital admissions or mortality cases to be grouped into separate noise categories.
- 2.11 As mentioned briefly earlier, the differences in effect size between the two models is marked, especially so for relative risk of hospital admissions for all three outcomes but especially for coronary heart disease at exposure levels of more than 60 dB and more than 63 dB.
- 2.12 When looking at mortality risk, as opposed to risk of hospital admission, the relative risk actually decreases to less than 1.0, for the noise exposure between 57 and 60 dB $LA_{eq, 16h}$, for stroke and cardiovascular disease in both models, although this effect is more pronounced for stroke. This suggests the possibility of a further confounding variable that has not been taken into account. The results also suggest a higher risk of mortality from coronary heart disease than cardiovascular disease. This is counter intuitive given that cardiovascular disease encompasses all the diseases of the heart and circulation, including coronary heart disease and stroke along with heart failure and congenital heart disease. It would be expected that the largest effect would be seen for the category of cardiovascular disease, and stroke and coronary heart disease would show smaller effects, as they are subsets of this.
- 2.13 For the night noise data, the upper limit cut-off is noise exposure of at least 55 dB, but it is not explained as to why this is the case. This appears to encompass a large range of noise levels in just one category, for example the risk factor could occur at much higher levels such as 69 dB, yet there is no distinction to allow for this possibility within the analysis and it would benefit from the refinement of noise categories.
- 2.14 It is acknowledged within the paper that it was not possible to have access to individual level information on confounders such as smoking, so results at area levels may not be applicable to individuals. It was not possible for the study to distinguish between short and long term effects of noise and length of residency in this study, which would merit further research. A potential source of bias may be the lack of information concerning the migration in and out of the study areas.

- 2.15 The differences between night time noise and day time noise could not be distinguished due to their high degree of correlation. The authors suggested that further research is needed to assess whether night time noise affecting sleep may be contributing to the observed results. In addition to possible causal relationships between aircraft noise and cardiovascular outcomes, it is important to consider the potential for confounding and ecological bias in this study. An important area for further research would be to determine the relative contribution of night time noise compared with daytime noise to the respective health endpoint.

Floud et al

- 2.16 The second study that included health effects around Heathrow was by Floud et al (2013), again from Imperial College, London. This European study was an extension to the Hypertension and Environmental Noise near Airports (HYENA) study, using self-reported data on heart disease and stroke between 2004 and 2006 from 4,712 people living near six European airports. This study examined road traffic noise and aircraft noise around London Heathrow, Amsterdam Schiphol, Stockholm Arlanda and Bromma, Milan Malpensa, Berlin Tegel and Athens Elephtherios Venizelos with the aim of investigating whether there is an association between exposure to aircraft noise or road traffic noise and heart disease and stroke.
- 2.17 In the HYENA study residents around the given airport were exposed to ranges of noise levels between less than 50 dBA to more than 60 dBA $LA_{eq, 16h}$. As part of the health questionnaire participants were asked to declare if they had ever been diagnosed with angina, myocardial infarction (MI) or stroke whilst at their current address. This represented the 'heart disease and stroke' factor within this study. Aircraft noise was estimated for annual average day time (0700-2300) $LA_{eq, 16h}$ and night time (2300-0700) L_{night} and road traffic noise was estimated using the 24 hour metric $LA_{eq, 24h}$. The lower limit cut-off levels were 35 dBA for daytime aircraft noise, 30 dBA for night time aircraft noise and 45 dBA for road traffic. The researchers appear to have chosen these very low noise exposures, because the information seemed to be available. Such low exposure data have not been validated and are typically associated with long-distance sound propagation with associated large uncertainty. Secondly, the aircraft noise values are from aircraft noise sources alone. However, overall ambient noise exposure levels in urban and suburban areas rarely drop below 40 dBA, so the cut-off levels are likely to be below ambient noise exposure levels in much of the study areas.
- 2.18 In those study, as a possible confounder, nitrogen dioxide (NO_2) was estimated at participants' addresses using dispersion modelling in the UK, Netherlands and Sweden.