Aircraft noise and cardiovascular disease near Heathrow airport in London: small area study

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ABSTRACT

Background. Few studies have investigated associations of aircraft noise with cardiovascular health. This study investigated associations with risk of stroke, coronary heart disease, and cardiovascular disease in the general population in areas exposed to noise from London Heathrow airport.

Methods. A small area study was conducted in 12 110 census output areas covering 3.6 million residents in Greater London and extending further west. Risks for hospital admissions and mortality from stroke, coronary heart disease and cardiovascular disease in 2001-05 were assessed in relation to aircraft noise in 2001 using a Poisson regression model including a random effect term.

Results. When areas experiencing the highest levels of daytime aircraft noise were compared with those experiencing the lowest levels (>63 dB v ≤51 dB LAeq,16h), the relative risk of hospital admissions for stroke was 1.24 (95% confidence interval 1.08 to 1.43), for coronary heart disease was 1.21 (1.12 to 1.31), and for cardiovascular disease was 1.14 (1.08 to 1.20) adjusted for age, sex, ethnicity, deprivation, and a smoking proxy (lung cancer mortality). Corresponding relative risks for mortality were of similar magnitude, although with wider confidence limits. Admissions for coronary heart disease and cardiovascular disease were particularly affected by adjustment for South Asian ethnicity, but robust to adjustment for particulate matter (PM10) air pollution, and road traffic noise, possible for London boroughs (population about 2.6

million). We could not distinguish between the effects of daytime or night time noise as these measures were highly correlated.

Conclusion. High levels of aircraft noise were associated with increased risks of stroke, coronary heart disease, and cardiovascular disease for both hospital admissions and mortality in areas near Heathrow airport in London. As well as the possibility of causal associations, alternative explanations such as residual confounding and potential for ecological bias should be considered.

INTRODUCTION

Although the literature on population annoyance associated with aircraft noise is extensive (Miedma & Vos 1998; WHO 2011) little research has been conducted on the potential effects of aircraft noise on cardiovascular health (WHO 2011). Most studies of the health effects associated with aircraft noise have focused on blood pressure and the risk of hypertension (Jarup et al 2008; Eriksson et al 2007; Eriksson et al 2010; Rosenlund et al 2001; Haralabidis et al 2008; Babich & van Kamp 2009). The few reports of aircraft noise and risk of stroke, coronary heart disease, or cardiovascular disease are inconsistent (Huss et al 2010; Sørensen et al 2011, Floud et al 2013), partly reflecting reduced statistical power

Heathrow airport, situated in a densely populated area in west London, is one of the busiest airports in the world. Reports have shown an association between aircraft noise, especially at night, and hypertension (Jarup et al 2008), acute increases in blood pressure (Haralabidis et al 2008), and self-reported cardiovascular disease (Floud et al 2013) in the population living near airports, including Heathrow. We investigated the risks of stroke, coronary heart disease, and cardiovascular disease hospital admissions and mortality in areas exposed to aircraft noise near Heathrow airport.

METHODS

The study area comprised 12 London boroughs and nine districts west of London exposed to aircraft noise related to Heathrow airport, defined as being partly or wholly within the 2001 50 dB noise contour for Heathrow aircraft during the daytime (LAeq,16h) supplied by the Civil Aviation Authority. Additionally, we had confounder data for particulate air pollution and road traffic noise for the 12 London boroughs (data for districts outside London were not readily comparable with the data available for London). We defined neighbourhoods (small areas) by using the national census geographical units, which are census output areas and super output areas. The study area comprised 12 110 census output areas (average 297 inhabitants, area 0.13 km2) and 2378 super output areas (1510 inhabitants, area 0.65 km2). We used the census output area as the unit of analysis for hospital admissions and the super output area, an aggregate of on average five census output areas, for mortality as

the numbers of deaths were insufficient for meaningful analyses at census output area level. We used Office for National Statistics annual mid-year population estimates by age and sex for 2001-05 at London borough or district level, which we then disaggregated to census output areas and super output areas using the UK 2001 census age-sex distribution.

Aircraft noise data were obtained from the Civil Aviation Authority on 10 m × 10 m grids. The noise data had been modelled using the UK Civil Aircraft Noise Contour Model ANCON, which uses information on flight paths of arriving and departing aircraft along with factors such as height, speed, and engine power to derive noise at ground level (Ollerhead et al, 1999). We calculated population weighted annual average noise levels for daytime and night time aircraft noise for census output areas and super output areas.

We extracted data on hospital admissions (main reason for admission, first episode of stay in a given year) using Hospital Episode Statistics (HES) from the Health and Social Care Information Centre and deaths (by underlying cause) for the study area, 2001-05, from Office for National Statistics and Department of Health data held by the UK Small Area Health Statistics Unit at Imperial College London. Data were obtained for stroke (ICD-10 codes I61, I63-I64, international classification of diseases, 10th revision), coronary heart disease (ICD-10 I20-I25), and cardiovascular disease (ICD-10 Chapter I) and then linked these by postcode (average 23 households) to census output area and super output area.

We included ethnicity, deprivation, and a smoking proxy at census output area and super output area level as potential confounders. Area level ethnic composition and deprivation from the 2001 census were obtained from the Office for National Statistics. For the two major ethnic groups in London, we categorised areas by South Asian ethnicity (census term “Asian or Asian British,” for which we included only “Indian,” “Pakistani,” and “Bangladeshi”) and black ethnicity (census term “Black or Black British,” which includes “Black Caribbean,” “Black African,” and “Other Black”). We used the following cut points: the national average (%) for England and Wales at census output area level (4% for South Asian, 2% for black ethnicity), double the national average (8%, 4%), and 50% South Asian or black ethnicity—areas where these comprised the majority ethnic group. This gave us four categories for each ethnicity, where the reference categories were less than or equal to the national

average (%) for that ethnic group (≤4% for South Asian and ≤2% for black ethnicity). The deprivation score used was Carstairs index (Carstairs & Morris 1991), categorised in fifths. As a proxy measure for area level smoking we used smoothed lung cancer mortality (ICD-10 codes C33-C34) relative risk estimates, 2005, for census output areas and super output areas since data on individual smoking or smoking prevalence were not available.

We grouped daytime aircraft noise and road noise into six categories from ≤51 to >63 dB in increments of 3 dB, Night time aircraft noise affected fewer areas and 5 dB categories (≤50, >50-55, and >55 dB) were used.

A Poisson regression with an additional random effect term to account for over-dispersion and residual heterogeneity was used to conduct a small area analysis of aircraft noise and the three cardiovascular outcomes, adjusted for potential confounders at area level (census output area or super output area): age, sex, South Asian and black ethnicity, deprivation, and smoking proxy (lung cancer mortality risk).

RESULTS

The study area population (2001 census) was 3.6 million. During 2001-05, 189 226 first episodes of hospital stay in a given year for cardiovascular disease (16 983 stroke, 64 448 coronary heart disease) and 48 347 cardiovascular disease related deaths (9803 stroke, 22 613 coronary heart disease) occurred in the study area.

For each of stroke, coronary heart disease, and cardiovascular disease the pattern (Figure 1) was of increasing risk of admission with increasing aircraft noise, and all linear tests for trend were statistically significant ($P<0.001$ to $P<0.05$). The risk of coronary heart disease in particular, and to a lesser extent cardiovascular disease, was noticeably reduced by adjustment for multiple confounders, in particular South Asian ethnicity. In multiple adjustment models, for daytime aircraft noise (>63 dB v ≤51 dB) the relative risk for stroke was 1.24 (1.08 to 1.43), for coronary heart disease was 1.21 (1.12 to 1.31), and for cardiovascular disease was 1.14 (1.08 to 1.20). Corresponding relative risks for night time noise (>55 dB v ≤50 dB) were 1.29 (1.14 to 1.46), 1.12 (1.04 to 1.20), and 1.09 (1.04 to 1.14).

The relative risks of mortality were numerically similar to those for hospital admissions at the higher noise levels, although confidence intervals were wider,

reflecting the smaller numbers of events. Tests for linear trend across noise categories in the fully adjusted models were significant (P<0.05) for daytime noise and coronary heart disease but not for stroke or cardiovascular disease, nor night time noise.

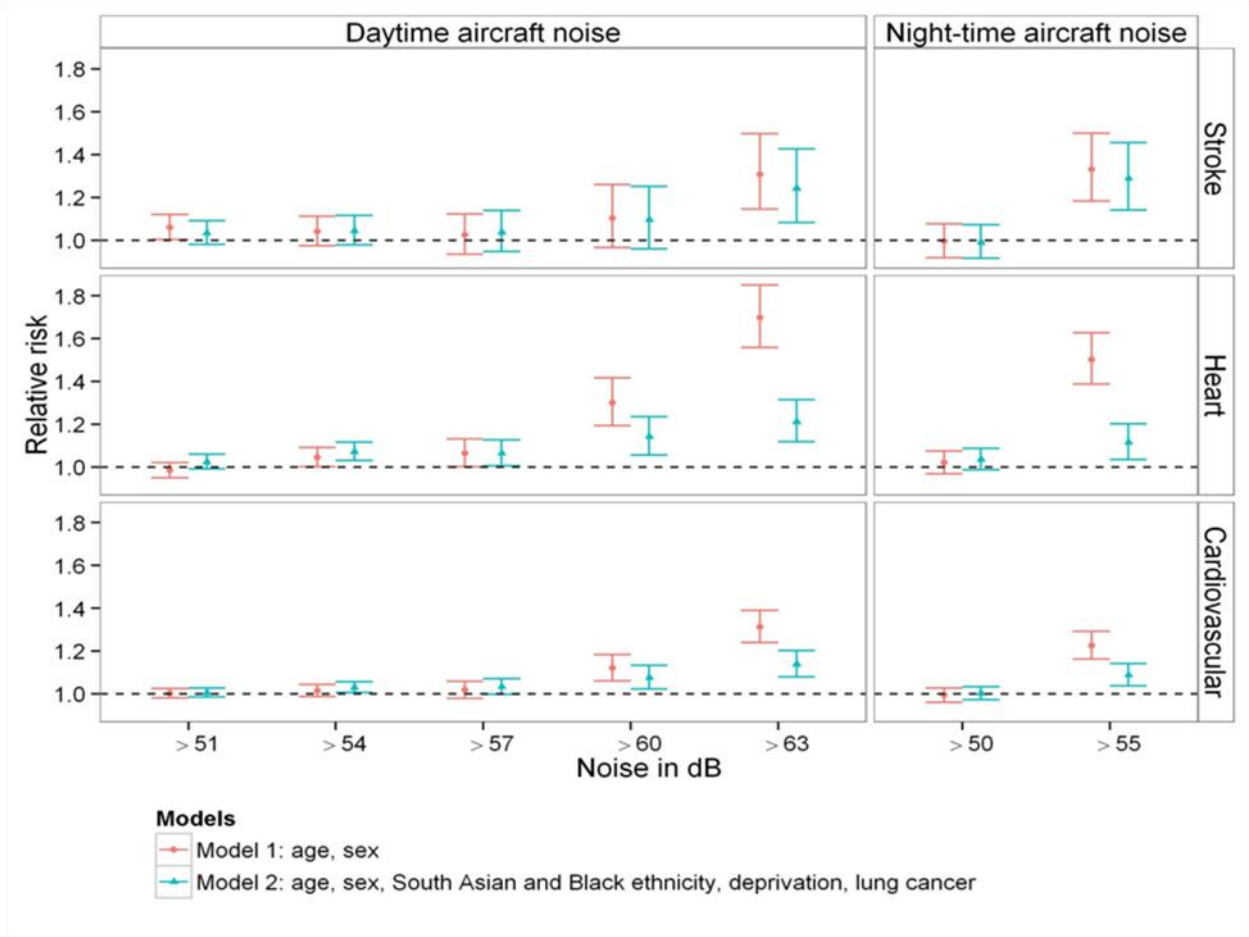

Figure 1: Relative risks (95% confidence intervals) for associations between hospital admissions for stroke, coronary heart disease, and cardiovascular disease in 2001-05 and annual population weighted average daytime aircraft noise (relative to ≤51 dB) and night time aircraft noise (relative to ≤50 dB) in 2001, in census output areas

DISCUSSION

Strengths of this study include the large general population sample, inclusion of both incident events (hospital admissions) and mortality, and wide range of aircraft noise

levels, providing sufficient statistical power to detect modest associations. Limitations include inability to adjust for confounders at individual level.

Admissions for coronary heart disease and to a lesser extent for cardiovascular disease were particularly affected by adjustment for South Asian ethnicity, which itself is strongly associated with risk of coronary heart disease (Balarajan 1991); so these risk estimates should be interpreted cautiously. We restricted our hospital admission analyses to the first admission within one calendar year; as we did not link across years it is possible that some may be readmissions if they occurred in different calendar years. However, point estimates at higher noise levels were similar for mortality and hospital admissions, making it less likely that this was an important source of bias.

Our results suggest that high levels of aircraft noise are associated with an increased risk of stroke coronary heart disease, and cardiovascular disease. As well as the possibility of causal associations, alternative explanations should be considered. These include the potential for incompletely controlled confounding and ecological bias, as we did not have access to individual level confounder data such as ethnicity and smoking. Further work to understand better the possible health effects of aircraft noise is needed, including studies clarifying the relative importance of night time compared with daytime noise.

REFERENCES

Babisch W, van Kamp I (2009). Exposure-response relationship of the association between aircraft noise and the risk of hypertension. Noise Health 11:161-8.

Balarajan R (1991). Ethnic differences in mortality from ischaemic heart disease and cerebrovascular disease in England and Wales. BMJ 302:560.

Carstairs V, Morris R (1991). Deprivation and health in Scotland. Aberdeen University Press;

Eriksson C, Rosenlund M, Pershagen G, et al (2007). Aircraft noise and incidence of hypertension. Epidemiology 18:716-21.

Eriksson C, Bluhm G, Hilding A, et al (2010). Aircraft noise and incidence of hypertension—gender specific effects. Environment Res 110:764-72.

Floud S, Blangiardo M, Clark C, et al (2013). Exposure to aircraft and road traffic noise and associations with heart disease and stroke in six European countries: a cross-sectional study. Environ Health Oct 16;12:89.

Gan WQ, Davies HW, Koehoorn M, Brauer M (2012). Association of long-term exposure to community noise and traffic-related air pollution with coronary heart disease mortality. Am J Epidemiol 175:898-906.

Haralabidis AS, Dimakopoulou K, Vigna-Taglianti F, et al (2008). Acute effects of night-time noise exposure on blood pressure in populations living near airports. Eur Heart J 29:658-64.

Huss A, Spoerri A, Egger M, Röösli M, Swiss National Cohort Study Group (2010). Aircraft noise, air pollution, and mortality from myocardial infarction. Epidemiology 21:829-36.

Jarup L, Babisch W, Houthuijs D et al. (2008) Hypertension and Exposure to Noise Near Airports: the HYENA Study. Environ Health Perspect 2008;116::329-33.

Miedema HME, Vos H (1998). Exposure-response relationships for transportation noise. J Acoust Soc Am 1998;104: 3432-45.

Rosenlund M, Berglind N, Pershagen G, et al (2001). Increased prevalence of hypertension in a population exposed to aircraft noise. Occup Environ Med 58:769-73.

Ollerhead JB, Rhodes DP, Viinikainen MS, et al (1999). The UK Civil Aircraft Noise Contour Model ANCON: improvements in version 2 (R&D Report 9842). Civil Aviation Authority.

Sørensen M, Hvidberg M, Andersen ZJ, et al (2011). Road traffic noise and stroke: a prospective cohort study. Eur Heart J 32:737-44.

World Health Organization (2011). Burden of disease from environmental noise. WHO, Regional Office for Europe. JRC, European Commission.

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