Impact of short-term aircraft noise on cardiovascular disease risk in the area surrounding London Heathrow airport: the RISTANCO epidemiological study

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Published December 2024
DOI: 10.3310/UTCE9104

Scientific summary

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Public Health Research 2024; Vol. 12: No. 13
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Scientific summary

Background

Long-term exposure to aircraft noise has been associated with small increases in risk for cardiovascular health outcomes but there are almost no short-term exposure studies. Relief periods are valued by residents under flight paths, whether in relation to planned flight path changes or because of weather patterns, but it is unclear whether these relief periods have population health benefits.

Research questions and objectives

The specific research questions were:

1. Is there a significant short-term impact of aircraft noise on cardiovascular morbidity and mortality?
2. Are there interactions with factors such as age, gender, ethnicity and deprivation that may function as effect modifiers?
3. Is there variability in risk estimates between areas with consistent patterns of noise exposure versus those with changing patterns of noise exposure?
4. How do risk estimates differ when using different noise metrics?

Objectives were:

1. to obtain daily estimates of day and night-time noise average exposure and number of noisy (flight) events for 2014–18 for the population living around London Heathrow airport;
2. to link the noise estimates to cardiovascular hospital admission and mortality data via postcode of residence;
3. to conduct a case-crossover analysis relating daily changes in aircraft noise to cardiovascular disease morbidity and mortality, taking account of relevant confounders that also change on a day-to-day basis such as temperature and air pollution;
4. to identify relevant interactions for areas with consistent patterns of noise exposure versus those with changing patterns of noise exposure and to explore interactions with age, gender, ethnicity and deprivation.

Methods and results

Data sources

- We worked with a specialist noise consultancy that modelled aircraft noise at different times of day, every day from 2014 to 2018, using a standard noise model, the Aviation Environmental Design Tool, for (1) noise levels expressed in decibels as equivalent continuous sound levels (LAeq) for eight time bands, and (2) number of aircraft noise events above defined noise thresholds (2018 only). The time bands were defined by the study scientific advisory board (relating to night-time, morning shoulder, morning, afternoon, evening, late evening, night-time shoulder, which correspond to aircraft operation periods). We provided input data for the model such as temperature and evaluated outputs against annual average Civil Aviation Authority (CAA) noise levels (that use the ANCON noise model).
- Our health outcomes were NHS Digital hospital admission records and mortality records from the Office for National Statistics for 2014–18 for cardiovascular outcomes, plus individual-level factors available from healthcare records (e.g. age and sex). We used data held by the Small Area Health Statistics Unit.

- We obtained confounder data from a number of sources including road traffic noise (University of Leicester modelled), rail noise (Department for Environment, Food and Rural Affairs), air pollution, area-level deprivation measures of Carstairs index (UK Census), avoidable death rate (UK government statistics), fuel poverty (Office for National Statistics) and ethnicity (NOMIS, provided by the Office for National Statistics).

Study area, study unit and population

The study area was designed to capture the outer bounds of the CAA annual-average aircraft noise contours in 2011 (these are produced around every 5 years; 2011 was also a Census year). This encompassed a boundary box that extends approximately 97 km east to west and 47 km north to south. Between 2014 and 2018, this included between 155,448 and 156,324 postcodes annually.

We used postcodes as the unit of analysis. On average, each postcode in the study area contained 53 residents [standard deviation (SD) 44] and 22 households (SD 17). In 2011, the total population of this boundary box was approximately 6.3 million people.

Descriptive analyses

The morning shoulder period (06.00–07.00 hours; mean: 50.92 dB; 90th percentile: 52.08 dB) and daytime (07.00–15.00 hours) were the noisiest periods (mean: 49.87; 90th percentile: 51.50 dB). On average, the night shoulder and night quota periods (23.30–04.30 hours) were the quietest.

Postcodes within the study area during daytime 07.00–15.00 hours experienced an average of 8 noisy flight events (> 65 dB), with 10% of postcodes experiencing 10 events. Morning shoulder (06.00–07.00 hours) had the second highest (90th percentile) but the third highest mean noisy flight events (mean = 3; 90th percentile = 9). During the night quota period (04.30–06.00 hours), the average number of noisy flight events (> 60 dB) per postcode was one.

Approaches to identifying respite and/or relief periods

We did not have information about trials or operational changes of flight paths over the period of the study. However, trials tend to cover relatively small areas. We identified one doctoral dissertation in the literature that used a natural experiment of the Early Morning Arrival Trial at Heathrow. The study examined the impact of night and early morning flight rerouting on medical expense, within four exclusion zones (two to the east and two to the west of Heathrow). During the trial (5 November 2012–31 March 2013), each week, the night and early morning (23.30–06.00 hours) aircraft movement was rerouted from one set of air traffic exclusion zones to non-exclusion areas. A difference-in-difference analysis found no difference in expenditure for CVD in zones where respite was implemented compared with control zones, but size of the affected area was small.

In our experiment, we therefore used the natural feature of wind direction changes that alter the flight paths as aircraft take off into the wind (broadly speaking 70% of the time Heathrow operates on a westerly pattern and 30% on an easterly), which meant that we could select from all days between 2014 and 2018 and all areas near the airport.

Our first approach was to identify areas that experienced pre-defined differences in noise exposures. Published laboratory research conducted for Heathrow airport (https://www.heathrow.com/company/local-community/noise/making-heathrow-quieter/respite-research; accessed 13 February 2023) has suggested that differences of 5–6 dB between successive sounds may be necessary for people to discern that there is a difference and that a difference of at least 7 or 8 dB may be needed between the average sound levels of two sequences of aircraft sounds to provide a valuable break from aircraft noise. We therefore investigated the number of areas that had detectable noise level changes compared with control areas that had more constant levels of noise using predefined cut-off levels referring to this report (e.g. 100+ days > 55 dB and 100+ days ≤ 50 dB in daytime periods). The number of postcodes identified with 5 dB or greater noise differences and durations of noisy/quiet days was small. We did not proceed to conduct health analyses using these criteria because the small sample size may have been insufficient to detect effects.

The approach we explored for health analysis was empirical and based on noise variability as seen in the whole dataset. To identify areas with changes in noise exposures we calculated the coefficients of variation (CoV) of daily aircraft noise levels by postcode for the entire dataset (all four seasons) or by season (summer, summer transition, winter and winter transition). We found that night-time (24.00–04.30 hours) had the highest mean CoV (67.33–74.16), followed by 04.30–06.00 and 23.00–24.00 hours. The variability of daytime aircraft noise tended to be lower.

Investigating daily aircraft noise exposure and material and health inequality

There were inequalities in aircraft noise exposure. We employed a random effects model with autoregressive first-order autoregression model disturbance to investigate the relationship between noise levels and quintiles of deprivation. We explored relationships with three different area-level measures related to deprivation: the Carstairs index (a composite measure from UK Census variables relating to poverty), the avoidable death rate (health inequality) and fuel poverty (wealth inequality).

We found that postcodes near Heathrow airport within quintile 1 (least deprived) of either the Carstairs index or avoidable death rate experienced the lowest daily noise levels between 2014 and 2018. While there was no clear exposure–response relationship between two deprivation measures (Carstairs index and fuel poverty) and three noise metrics [equivalent continuous sound pressure levels during 07.00–19.00 hours (Lday), during 19.00–23.00 hours (Leve) and for 24 hours], we observed a gradient between equivalent continuous sound pressure level during 23.00–07.00 hours (Lnight) and Carstairs index and avoidable death rate.

Short-term impact of aircraft noise on cardiovascular disease

We used a time-stratified case-crossover study design, in which the days when an outcome of interest occurred are matched with control days within the same month and on the same day of the week and the exposure on case and control days are compared. This approach accounts by design for confounding variables that are invariant or slowly time variant, such as age and sex. We adjusted for confounding variables that change over short periods, such as concentrations of particulate matter less than 2.5 µm in diameter, temperature and holiday periods. We included all recorded hospitalisations (n = 442,442) and deaths (n = 49,443) in 2014–18 due to CVD in the analysis and used conditional logistic regression to estimate odds ratios (OR). We observed a statistically significant increase in risk for CVD hospital admissions for a 5-dB increment in noise during Leve [Level OR 1.005, 95% confidence interval (CI) 1.000 to 1.010], particularly from 22.00 to 23.00 hours [OR 1.006, 95% CI 1.002 to 1.010], but did not detect statistically significant associations for other periods or for mortality. If the association is causal, it suggests that sleep disturbance may be a mechanism.

We found effect modification by age, sex, ethnicity, deprivation and season (winter, winter transition, summer and summer transition).

When stratified by CoV, our results showed a statistically significant adverse association between evening noise levels (19.00–22.00 hours, 22.00–23.00 hours and 23.00–24.00 hours) and hospital admission for CVD in low (below mean) CoV postcodes but not in high CoV postcodes. To explore whether fewer relief periods these low CoV areas were those with higher noise levels (potentially suggesting high noise and less relief periods), we examined mean noise levels. For the latter two periods, mean noise levels were higher in the low CoV postcodes (41 dB vs. 37 dB for 22.00–23.00 hours; 31 dB vs. 24 dB for 23.00–24.00 hours). However, for the period 19.00–22.00 hours, the mean noise levels were 41 dB in low CoV areas compared with 43 dB in high CoV areas. We therefore cannot readily infer that lack of relief periods (or at least some periods of lower noise exposure) was associated with hospitalisation.

Conclusions

Our study focused on the impact of short-term aircraft noise on cardiovascular morbidity and mortality. Our findings suggest an association between short-term exposure to noise during evening and night-time hours, and an elevated risk of hospital admissions (but not deaths) for CVD. Our findings also suggested that the variability of noise exposure may play an important role in its relationship with health outcomes. Our results could be useful for residents, future health studies and a variety of other studies.

Recommendations for future research

- Further studies are needed to assess the impact of intervention on short-term aircraft noise exposure on CVD – this is one of the first such studies to date.
- Further research is needed to investigate the relationship between noise variability and the risk of CVD, potentially starting with laboratory experimental studies or field studies of flight path changes, and using intermediate continuous outcomes, such as blood pressure, rather than binary outcomes.
- Further research is needed to explore effect modifiers, such as introducing noise insulation measures for areas most affected by aircraft noise, which may have important implications for future policy interventions.
- More research is needed to explore associations between deprivation and noise exposure levels.
- Exploring the relationship between outdoor and indoor noise exposure levels is important.

Implications for future studies

- Standard noise metrics such as Lday and Lnight may not capture periods where exposure has most impact on health and use of alternative noise metrics need to be explored.
- Future studies on the health effects of aircraft noise pollution are advised to take noise variability into account.
- Future epidemiological studies are recommended to consider different metrics of health deprivation as a potential confounder and effect modifier.

Funding

This award was funded by the National Institute for Health and Care Research (NIHR) Public Health Research programme (NIHR award ref: 15/192/13) and is published in full in *Public Health Research*; Vol. 12, No. 13. See the NIHR Funding and Awards website for further award information.

Public Health Research

ISSN 2050-439X (Online)

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This article

The research reported in this issue of the journal was funded by the PHR programme as award number 15/192/13. The contractual start date was in November 2017. The draft manuscript began editorial review in November 2022 and was accepted for publication in May 2023. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The PHR editors and production house have tried to ensure the accuracy of the authors' manuscript and would like to thank the reviewers for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this article.

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