The association between aircraft noise levels and incident hypertension in the DEBATS longitudinal study

Aboud Kourieh[1], Lise Giorgis-Allemand[1], Liacine Bouaoun[2], Marie Lefèvre[1, 3], Bernard Laumon[4] and Anne-Sophie Evrard[1].

[1] Univ Lyon, Univ Gustave Eiffel, IFSTTAR, Univ Lyon 1, Umrestte, UMR T_9405, F-69675 Bron, France
[2] International Agency for Research on Cancer, F-69372 Lyon, France
[3] Now at: Technical Agency for Information on Hospital Care, F-69329 Lyon, France
[4] Univ Gustave Eiffel, IFSTTAR, TS2, F-69675 Bron, France

Corresponding author's e-mail address: aboud.kourieh@univ-eiffel.fr

ABSTRACT

Although aircraft noise exposure was found to be associated with higher risk of hypertension in cross-sectional studies, a limited number of longitudinal studies have addressed this issue. This study aimed to investigate the association between exposure to aircraft noise and the incidence of hypertension. This study included in 2013 1,244 adults living near three French airports. Systolic and diastolic blood pressure, and demographic and lifestyle risk factors were collected at baseline and after two and four years during face-to-face interviews. Aircraft noise exposure was estimated for each participant's home address using noise maps. Analysis was performed using mixed Poisson and linear regression models adjusted on potential confounders. A 10 dB(A)-increase in aircraft noise levels was associated with higher hypertension incidence (IRR (Incidence Rate Ratio) =1.33 (95%CI=1.00-1.78) for L_{den}). The association for L_{night} was at the borderline of statistical significance (IRR=1.28 (95%CI=0.98-1.67)). Systolic and diastolic blood pressure also increased with all noise indicators. These results strengthen those obtained from cross-sectional analysis of the data collected at inclusion and support the hypothesis that aircraft noise exposure may be considered as a risk factor of hypertension.

INTRODUCTION

Noise pollution is a major environmental issue. Epidemiological studies have previously linked aircraft noise exposure to several health risks including hypertension [1–3].

DEBATS is an individual longitudinal study aimed to evaluate the possible effects of aircraft noise exposure on the health of the population living near airports in France. The present paper presents the results of longitudinal analyses of the association between aircraft noise levels and the incidence of hypertension.

METHODS

Study population

The study protocol was described in detail elsewhere [2, 4]. Briefly, in 2013, the baseline study included 1,244 adults living near one of three major French airports (Paris-Charles-de-Gaulle, Lyon-Saint-Exupéry, and Toulouse-Blagnac). The study sample was randomly selected from the residents after stratifying for aircraft noise exposure categories (<50 dB(A), 50-54 dB(A), 55-59 dB(A) and >=60 dB(A)). These categories were defined on the basis of the most recent aircraft noise contours in terms of day-evening-night aircraft noise levels (L_{den}).

Questionnaires

At baseline in 2013 (T0) and then two (T2) and four (T4) years later, participants responded to a similar questionnaire during face-to-face interviews with trained interviewers. Collected information included demographic and socioeconomic characteristics; anthropometric measurements (height and weight); personal medical history and lifestyle factors, including tobacco and alcohol consumption and physical activity.

Blood pressure and hypertension

At T0, T2 and T4, the interviewer measured participant's systolic blood pressure (SBP) and diastolic blood pressure (DBP) using a validated, automated BP instrument. He performed the first measurement after a 5-minute rest at the beginning of the interview and a second measurement after a 1-minute interval. The mean of these two readings was used to define SBP and DBP for the following analyses. The interviewer recorded a third measurement about 1 hour later. This last measurement was used as a validity check to exclude participants for whom it was significantly different (±20 mm Hg) from the first two.

Either when their BP levels exceeded the WHO predefined threshold (SBP≥140 mm Hg or DBP≥90 mm Hg) [5], or if participants declared a prior diagnosis of hypertension by a physician as well as the use of antihypertensive medication, participants were considered hypertensive.

Aircraft noise assessment

Outdoor aircraft noise exposure at each participant's home address was assessed in 1 dB(A) intervals using noise maps produced by the French Civil Aviation Authority with the Integrated Noise Model (INM) [6]. Four noise indicators were calculated and used in the statistical analyses as continuous variables (L_{den}, L_{night}, $L_{Aeq,24h}$ and $L_{Aeq,6h\text{-}22h}$).

Statistical analysis

In the current longitudinal analyses, the incidence of hypertension was the primary outcome. It was defined as being classified as hypertensive for the first time during the study. Hence, participants with hypertension at T0 were excluded from the analyses. In addition, participants' observations were subsequently excluded at T4 if they were considered hypertensive at T2.

Adjusted mixed Poisson regression models with a participant-level random intercept were applied to investigate associations between the incidence of hypertension and aircraft noise exposure levels. Associations are reported using Incidence Rate Ratios (IRRs), which are the exponentials of the beta coefficients, and expressed for 10 dB(A) increase of aircraft noise

exposure with corresponding 95% confidence intervals (95% CIs). In these models, the outcome, the incidence of hypertension, was regressed against each noise level indicator and the confounders measured at the previous survey (time-1) to ensure that the measurements precede the onset of hypertension [7]. Thus, the survey indicator included in the models had two levels (0/2).

Linear mixed models with participant-specific random intercepts were applied to investigate the associations between systolic and diastolic blood pressure and aircraft noise exposure after adjustment for the previously mentioned confounders and the survey indicator. The outcome, SBP or DBP, and the confounders in these models were measured at the same survey and the survey indicator had three levels (0/2/4). Each level of the survey indicator represents the corresponding survey T0, T2 and T4, respectively.

The following major confounding factors were controlled for in the multivariate analyses for both Poisson and linear mixed models: gender, age (continuous), body mass index (BMI, in three categories: (underweight or normal/overweight/obesity), physical activity (yes/no), occupational activity (yes/no) and alcohol consumption (in three categories: no/light/moderate or heavy). The use of antihypertensive medication (yes/no) was also introduced into DBP and SBP models.

Analyses were carried out for each aircraft noise level indicator separately, and all associations were estimated per 10 dB(A) increase in noise levels. Analyses were performed using SAS 9.4 software with a significance level of $P<0.05$.

RESULTS

There were 1,230 participants (687 women and 543 men) at baseline, 984 (543 women and 441 men) at the first follow-up (T2) and 806 (434 women and 372 men) at the second follow-up (T4) included in present analysis.

The prevalence of hypertension was estimated to 35%, 36% and 38% at T0, T2 and T4, respectively. A total of 80 (8%) and 47 (6%) incident cases of hypertension were identified at T2 and T4, respectively.

Table 1 presents the results obtained from the two Poisson models exploring separately the effect of exposure to aircraft noise in terms of L_{den} and L_{night} on the incidence of hypertension. A 10-dB(A) increase in aircraft noise levels in terms of day-evening-night exposure (L_{den}) was significantly associated with a higher incidence of hypertension. The association for nighttime noise exposure (L_{night}) was at the borderline of statistical significance.

A significantly higher incidence of hypertension was also observed with each 10-dB(A) increase in 24-hour noise exposure ($L_{Aeq,24h}$) and daytime noise exposure ($L_{Aeq,6h\text{-}22h}$) (results not shown).

Table 1: Aircraft noise indicators and hypertension incidence: results of the adjusted mixed Poisson regression models

Indicator of exposure	IRR*	95% CI	p-value
L_{den}	1.33	1.00–1.78	0.05
L_{night}	1.28	0.98–1.67	0.06

* Per 10 dB(A) increase in aircraft noise exposure. Adjusted for age, gender, BMI, physical activity, alcohol consumption, occupational activity and survey dummy variable.

A statistically significant increase in systolic and diastolic BP was also found for a 10-dB(A) increase in aircraft noise exposure for all of the four indicators (results not shown).

DISCUSSION

In the present longitudinal study, 127 incident cases of hypertension (80 at T2 and 47 at T4) were identified over a four-year period. Our results indicate that increasing levels of aircraft noise exposure were associated with a higher incidence of hypertension. A similar positive association was also found for systolic and diastolic blood pressure. These results confirm those of a previous cross-sectional analysis from the DEBATS baseline observations, where a significant relationship was found between aircraft noise and the risk of hypertension among men [2].

Several previous cross-sectional studies have also shown that exposure to aircraft noise increases the risk of hypertension. However, a recent WHO review considered the evidence inconclusive, with a pooled Relative Risk (RR) of 1.05 (95% CI: 0.95–1.17) per 10-dB (A) increase in L_{den} [1].

Our results are consistent with those of the only two longitudinal studies available on the subject [8, 9]. Indeed, Pyko et al. found a statistically significant association between the incidence of hypertension and aircraft noise exposure: Hazard Ratio (HR) = 1.16 (95% CI: 1.08–1.25) per 10-dB(A) increase in L_{den} [8]. Dimakopoulou et al. also reported a positive association in a HYENA sub-study carried out in Athens (Greece): Odds Ratio (OR) = 2.63 (95% CI: 1.21–5.71) per 10-dB(A) increase in L_{night}. [9].

The present study is one of the very few longitudinal studies investigating the potential effect of noise on hypertension in Europe and the first in France. Our results support the hypothesis that aircraft noise exposure may be considered as a risk factor for hypertension. Potential biases may have occurred in this study but they are likely to be limited.

Acknowledgements

The Airport Pollution Control Authority (Acnusa) requested the French Institute of Science and Technology for Transport, Development and Networks (Ifsttar) to carry out this study. The authors would like to thank them for their confidence.

The authors are grateful to all study participants as well as interviewers.

The authors also thank Paris Airports and the French Civil Aviation Authority for providing noise exposure maps, and are also grateful to Inès Khati for her participation in the implementation of the study.

REFERENCES

[1] Van Kempen, E.; Casas, M.; Pershagen, G. and Foraster, M.: WHO environmental noise guidelines for the European region: a systematic review on environmental noise and cardiovascular and metabolic effects: a summary, International journal of environmental research and public health, **15** (2018), no. 2, p. 379.

[2] Evrard, A.-S.; Lefèvre, M.; Champelovier, P.; Lambert, J. and Laumon, B.: Does aircraft noise exposure increase the risk of hypertension in the population living near airports in France?, Occupational and environmental medicine, **74** (2017), no. 2, pp. 123–129.

[3] WHO: Burden of disease from environmental noise: Quantification of healthy life years lost in Europe, World Health Organization. Regional Office for Europe, 2011.

[4] Evrard, A.-S.; Bouaoun, L.; Champelovier, P.; Lambert, J. and Laumon, B.: Does exposure to aircraft noise increase the mortality from cardiovascular disease in the population living in the vicinity of airports? Results of an ecological study in France, Noise & health, **17** (2015), no. 78, p. 328.

[5] Whitworth, J.A. and Group, I.S. of H.W.: 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension., Journal of hypertension, **21** (2003), no. 11, p. 1983.

[6] He, H.; Dinges, E.; Hermann, J.; Rickel, D.; Mirsky, L.; Roof, C.; Boeker, E.; Gerbi, P. and Senzig, D.A.: Integrated Noise Model (INM) version 7.0 user's guide2007.

[7] Eze, I.C.; Foraster, M.; Schaffner, E.; Vienneau, D.; Héritier, H.; Pieren, R.; Thiesse, L.; Rudzik, F.; Rothe, T. and Pons, M.: Transportation noise exposure, noise annoyance and respiratory health in adults: A repeated-measures study, Environment international, **121** (2018), pp. 741–750.

[8] Pyko, A.; Lind, T.; Mitkovskaya, N.; Ögren, M.; Östenson, C.-G.; Wallas, A.; Pershagen, G. and Eriksson, C.: Transportation noise and incidence of hypertension, International journal of hygiene and environmental health, **221** (2018), no. 8, pp. 1133–1141.

[9] Dimakopoulou, K.; Koutentakis, K.; Papageorgiou, I.; Kasdagli, M.-I.; Haralabidis, A.S.; Sourtzi, P.; Samoli, E.; Houthuijs, D.; Swart, W. and Hansell, A.L.: Is aircraft noise exposure associated with cardiovascular disease and hypertension? Results from a cohort study in Athens, Greece, Occup Environ Med, **74** (2017), no. 11, pp. 830–837.