



Aircraft noise exposure and subjective sleep quality in the DEBATS longitudinal study

Lise Giorgis-Allemand¹, Aboud Kourieh¹, Bernard Laumon², Marie Lefèvre^{1,3}, Damien Léger⁴,
Ali-Mohamed Nassur^{1,5}, Anne-Sophie Evrard¹

¹ Univ Lyon, Univ Gustave Eiffel, IFSTTAR, Univ Lyon 1, UMRESTTE, UMR_T9405, F-69675 Bron, France (corresponding author)

² TS2, Univ Gustave Eiffel, IFSTTAR, F-69675 Bron, France

³ Now at: Technical Agency for Information on Hospital Care, F-69329 Lyon, France

⁴ Université Paris Descartes, APHP, Hôtel-Dieu de Paris, Centre du Sommeil et de la Vigilance et EA 7330 VIFASOM, F-75004 Paris, France

⁵ Now at: Action Against Hunger, F-75854 Paris, France

Corresponding author's e-mail address: lise.giorgis-allemand@univ-eiffel.fr

ABSTRACT

Aircraft noise exposure is known to impact human health, in particular sleep.

We aimed to characterize the association between aircraft noise exposure and subjective sleep quality.

The DEBATS study included 1,244 participants living near three French major airports. Participants answered in 2013, 2015 and 2017 detailed face-to-face interview. Outdoor aircraft noise levels were estimated at each home address using noise maps. Longitudinal analyses were performed using logistic mixed models adjusted on potential confounders.

In 2013, 9% of the participants had a short time in bed (≤ 6 h) (respectively 8% in 2015 and 6% in 2017) while 30% felt rather or very tired after a normal night in 2013 (24% in 2015 and 23% in 2017). A 10 dB(A) increase in L_{den} levels was associated with a short time in bed (OR=3.13; 95% confidence interval: 2.14-4.56) and with a feeling tired after a normal night (OR=1.28; 95%CI: 1.01-1.61).

In our longitudinal study, increased aircraft noise exposure was associated with decreased subjective sleep quality. Nevertheless, effects of annoyance due to aircraft noise and noise sensitivity must be investigated as they could mediate or moderate the observed associations.

INTRODUCTION

Noise exposure is known to impact human health [1]. Association between sleep disturbance and aircraft noise has been observed in epidemiological studies in several countries [2]. In France, cross-sectional analyses of baseline data from the DEBATS (Discussion on the health effects of aircraft noise) longitudinal study highlighted a decreased subjective [3] and objective [4, 5] sleep quality around three airports. However, these results must be confirmed by longitudinal analyses based on the follow-up of the participants.

This paper aimed to characterize the association between aircraft noise levels and subjective sleep quality through longitudinal analyses in the DEBATS study.

METHODS

Study population

In 2013, 1,244 participants older than 18 were recruited nearby three major French airports (Paris-Charles de Gaulle, Lyon-Saint Exupéry and Toulouse-Blagnac). They were randomly selected by phone survey and the recruitment was stratified on four aircraft noise categories. These categories (<50 dB(A), 50-54 dB(A), 55-59 dB(A), ≥60 dB(A)) were based on the day-evening-night equivalent level (L_{den}) from noise maps (see exposure assessment). At baseline in 2013, all participants answered a detailed face-to-face interview at home [6]. Two (first follow-up in 2015) and four (second follow-up in 2017) years after the recruitment, the participants were contacted to answer a similar follow-up questionnaire.

Exposure assessment

Aircraft noise exposure in terms of L_{den} was estimated in 1-dB(A) intervals for each participant with a linkage between noise maps and home addresses using a geographic information system (GIS) technique. If a participant moved between two interviews but stayed in the study area, aircraft noise exposure was also estimated at the new home address. Noise map produced with the Integrated Noise Model by Paris Airports for 2008 was used for Paris-Charles de Gaulle airport, while noise maps produced by the French Civil Aviation Authority for 2003 was used for Toulouse-Blagnac and for 2004 for Lyon-Saint Exupéry.

Study outcomes

Subjective sleep quality was assessed using time in bed and feeling tired after a normal night. Time in bed was estimated from the questionnaires as the difference between the time of going to sleep and the time of getting up and dichotomized as short time in bed (≤ 6 hours) versus normal and long time in bed (> 6 hours). For feeling tired after a normal night, participants answered a four-scale question that was dichotomized as feeling tired (very or rather tired) versus feeling not tired (rather or well rested).

Statistical analyses

Longitudinal analyses were performed using logistic mixed models with subject-specific random intercept and adjusted on follow-up. Models were additionally adjusted on the following a priori confounders: gender, age (continuous), education level (three categories: before

baccalaureate, baccalaureate, after baccalaureate), marital status (three categories: single, married, divorced or widowed), active smoking (three categories: nonsmoker, ex-smoker, actual smoker), alcohol consumption (three categories: no, follow recommendations, more than recommended), physical activity (two categories: yes, no), self-reported health (two categories: fair or poor, good or excellent), body mass index (three categories: obesity, overweight, normal or underweight), self-reported anxiety (two categories: extremely or a lot, moderately or slightly or not at all) and self-reported depression (two categories: extremely or a lot, moderately or slightly or not at all).

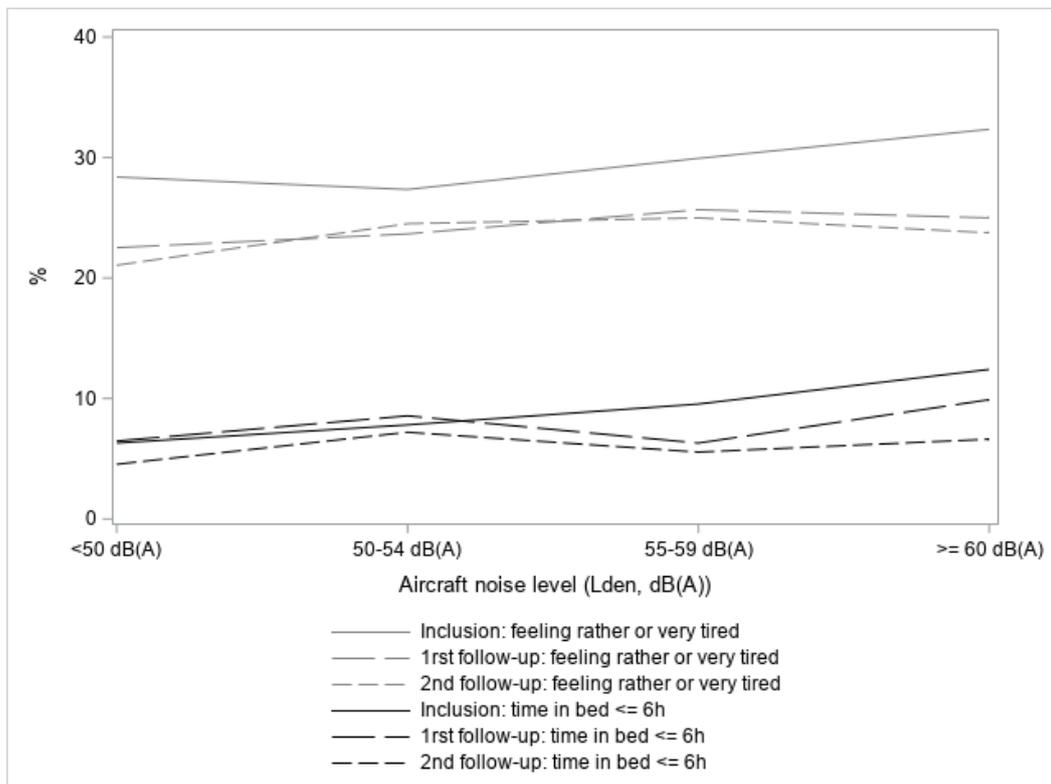
Several sensitivity analyses were conducted by running the main adjusted regression models 1) excluding retired people, 2) excluding night workers and flexible hours workers, 3) excluding people who moved in the five years before inclusion and 4) excluding lost to follow-up participants.

RESULTS

Study population

Among the 1,244 participants included in the study in 2013, 992 answered to the first followed-up questionnaire in 2015 and 811 to the second follow-up questionnaire in 2017. At baseline, 9% of the participants had a time in bed less or equal to 6h (respectively 8% at first follow-up and 6% at second follow-up) while 30% felt rather or very tired after a normal night (respectively 24% at first follow-up and 23% at second follow-up) (Figure 1).

Figure 1: Percentage of participants with a short time in bed or feeling tired after a normal night by follow-up and noise levels



Aircraft noise and subjective sleep quality

A 10 dB(A) increase in aircraft noise levels in terms of L_{den} was associated with a short time in bed (Odds Ratio OR=3.13; 95% confidence interval CI: 2.14-4.56) and with feeling tired after a normal night (OR=1.28; 95% CI: 1.01-1.61). Results remain similar when sensitivity analyses were conducted (results not shown), except for feeling tired after a normal night when analyses were restricted to the 985 participants who did not move in the five years before inclusion (OR per 10 dB(A) increase in L_{den} =1.18; 95% CI: 0.90-1.54).

DISCUSSION

In our longitudinal study, we observed that increased aircraft noise exposure was associated with a deterioration of the subjective sleep quality characterized by a short time in bed and feeling tired after a normal night. These results confirm those of the cross-sectional analyses conducted at baseline [3] and are in accordance with one cross-sectional study around Schiphol airport in Amsterdam (Netherlands) that found an increased risk of tiredness when exposed to higher levels of aircraft noise [7]. Regarding subjective time in bed, one study around Kunsan military airport (Republic of Korea) observed a trend to reduced sleep duration measured by Pittsburg Sleep Quality Index subscale with higher levels of aircraft noise, but without adjusting for any confounders [8].

Misclassification bias may have occurred in our study as aircraft noise exposure was not measured in bedroom and as sleep quality was subjectively evaluated. Information bias [2] is less likely to have occurred as the question used to define subjective sleep quality did not refer to aircraft noise. However, questions about subjective sleep quality were included after the ones about aircraft noise exposure, which could have induced some bias in the participant's answers.

The results observed in the present study must be completed by a study including other subjective sleep parameters and using other noise indicators. They also need to be confirmed by studies conducting measurements of objective sleep quality and acoustic measurements in the bedroom of the participants in order to better determine their aircraft noise exposure. This was the objective of the sleep study included in DEBATS, whose analyses are still in progress.

Finally, effects of annoyance due to aircraft noise and noise sensitivity must be investigated as they could mediate or moderate the observed associations.

ACKNOWLEDGEMENTS

The Airport Pollution Control Authority (Acnusa) requested that the Gustave Eiffel University (ex French Institute of Science and Technology for Transport, Development, and Networks, IFSTTAR) carry out this study. The authors would like to thank them for their confidence. The authors are grateful to all the participants in the study and to their interviewers. The authors also thank Paris Airports and the French Civil Aviation Authority for providing noise exposure maps, I. Khati for her participation in the implementation of the study and L. Bouaoun for his help with the statistical analyses.

REFERENCES

- [1] Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *Lancet*, 383(9925), 1325-1332. [https://doi.org/10.1016/S0140-6736\(13\)61613-X](https://doi.org/10.1016/S0140-6736(13)61613-X)
- [2] Basner, M., & McGuire, S. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. *International Journal of Environmental Research and Public Health*, 15(3), 519. <https://doi.org/10.3390/ijerph15030519>
- [3] Nassur, A. M., Lefevre, M., Laumon, B., Leger, D., & Evrard, A. S. (2017). Aircraft Noise Exposure and Subjective Sleep Quality: The Results of the DEBATS Study in France. *Behavioral sleep medicine*, 1-12. <https://doi.org/10.1080/15402002.2017.1409224>
- [4] Nassur, A.-M., Léger, D., Lefèvre, M., Elbaz, M., Miettlicki, F., Nguyen, P., ... Evrard, A.-S. (2019). The impact of aircraft noise exposure on objective parameters of sleep quality: results of the DEBATS study in France. *Sleep Medicine*, 54, 70-77. <https://doi.org/10.1016/j.sleep.2018.10.013>
- [5] Nassur, A.-M., Léger, D., Lefèvre, M., Elbaz, M., Miettlicki, F., Nguyen, P., ... Evrard, A.-S. (2019). Effects of Aircraft Noise Exposure on Heart Rate during Sleep in the Population Living Near Airports. *International Journal of Environmental Research and Public Health*, 16(2). <https://doi.org/10.3390/ijerph16020269>
- [6] Evrard, A. S., Lefèvre, M., Champelovier, P., Lambert, J., & Laumon, B. (2016). Does aircraft noise exposure increase the risk of hypertension in the population living near airports in France? *Occupational and Environmental Medicine*, 74(2), 123-129. <https://doi.org/DOI 10.1136/oemed-2016-103648>
- [7] Franssen, E. A., van Wiechen, C. M., Nagelkerke, N. J., & Lebrecht, E. (2004). Aircraft noise around a large international airport and its impact on general health and medication use. *Occupational and Environmental Medicine*, 61(5), 405-13. <https://doi.org/DOI 10.1136/oem.2002.005488>
- [8] Kim, S. J., Chai, S. K., Lee, K. W., Park, J.-B., Min, K.-B., Kil, H. G., ... Lee, K. J. (2014). Exposure-Response Relationship Between Aircraft Noise and Sleep Quality: A Community-based Cross-sectional Study. *Osong Public Health and Research Perspectives*, 5(2), 108-114. <https://doi.org/10.1016/j.phrp.2014.03.004>