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Pilot Field Study on the Effects of Aircraft Noise on Sleep Around Atlanta International Airport

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ABSTRACT

Aircraft noise can disrupt sleep and impair recuperation. The most recent US investigation on the effects of aircraft noise on sleep was conducted more than 20 years ago. Since then, traffic patterns and noise levels produced by single aircraft have changed substantially. It is therefore important that field studies be conducted in the U.S. to acquire current data on sleep disturbance relative to varying degrees of noise exposure. To inform the design of a larger national study, a pilot field study was conducted around Atlanta Airport. The primary goal was to assess feasibility of acquiring acoustical and physiological data with no investigator on site and equipment mailed to participants who then applied electrodes and started and stopped measurements each night on their own. We mailed 4080 recruitment questionnaires to randomly selected households exposed to aircraft noise (≥35 dB $LA_{\mathrm{Eq,23\text{-}07,outdoor}}$). Among the 407 respondents, 34 participated in the unattended five night in-home study. Indoor sound levels were determined via measurement. Arousal from sleep was recorded via a device measuring body movement and electrophysiological heart rate. Self-reported sleep was assessed with morning questionnaires. Several ways to improve data quantity and quality were identified. Overall, the approach was found to be feasible.

Keywords: Aircraft noise; sleep; physiologic field study; postal questionnaire study

1. INTRODUCTION

Aircraft noise can disturb sleep and impair recuperation (1-3). The most recent US investigation on the effects of aircraft noise on sleep was conducted more than 20 years ago. Since then, traffic patterns and noise levels produced by single aircraft have changed substantially. It is therefore important that field studies be conducted in the U.S. to acquire current data on sleep disturbance relative to varying degrees of noise exposure.

As self-assessments of sleep are unreliable, an inexpensive yet sound study methodology is needed for field studies on the effects of aircraft noise on sleep. For this purpose, the authors developed an automatic ECG-based algorithm for the detection of changes in heart rate associated with cortical arousals (4). This algorithm was later revised to better reflect EEG-based awakenings, and actigraphy-based body movements were included as one of the predicting signals (5). This methodology was first piloted in a field study on the effects of aircraft noise on sleep around Philadelphia International Airport (PHL). In this study, investigators were still on site for equipment setup and collection on the first and last day of the study. While feasible, this approach would make a national sleep study around multiple U.S. airports a logistical challenge and expensive. Earlier work by the authors demonstrated that ECG electrodes and actigraphs are non-invasive and can be easily applied by study participants themselves, greatly reducing methodological study cost compared to fully attended studies. In a pilot study presented in this report, the methodology of using ECG and actigraphy to monitor sleep was implemented in a second – this time unattended – pilot field study on the effects of aircraft noise on sleep around Atlanta Hartsfield-Jackson International Airport (ATL).

The primary objective of this study was to continue improving study methodology, in particular the quality and quantity of data that could be obtained when recruiting participants by postal

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questionnaire, shipping them the physiological and noise measurement equipment, and the setup of the equipment and recording of data by the participants themselves, unattended. A secondary objective of the study was to compare objective and subjective measures of sleep and health between groups exposed to different levels of nocturnal aircraft noise (not reported here).

2. METHODS

We mailed 4080 questionnaires containing items on sleep, health and noise disturbance to residences around ATL that were exposed to at least 35 dB L_{Night} ($LA_{Eq,23\text{-}07,outdoor}$) aircraft noise (see Figure 1). A number of different mailing strategies were adopted to maximize response rates.

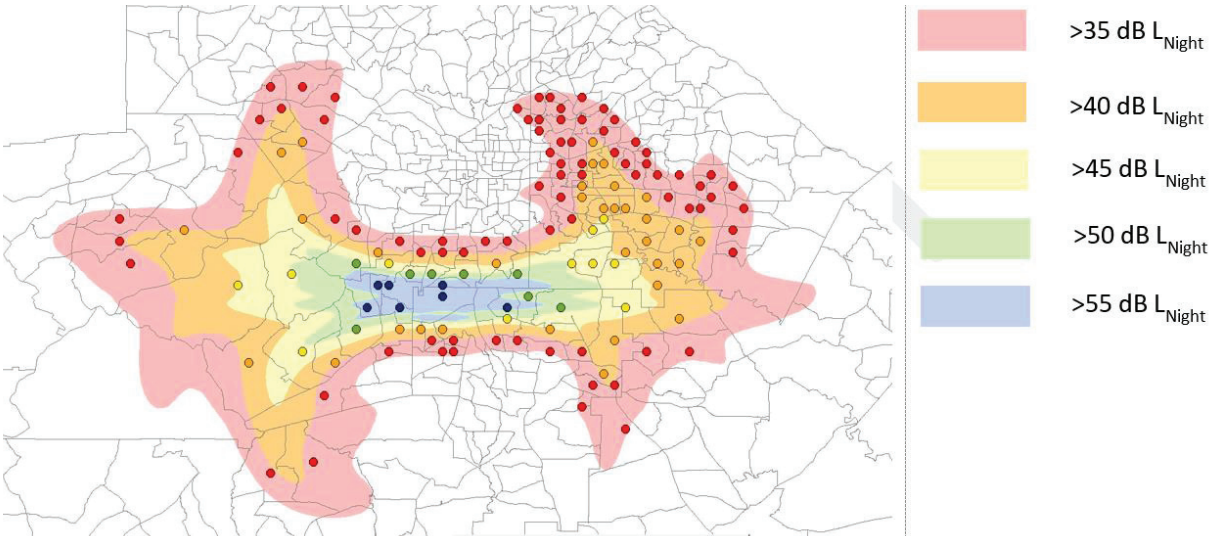

Figure 1: Noise exposure contours and population weighted centroid of census tracts around Atlanta Hartsfield-Jackson International Airport (ATL).

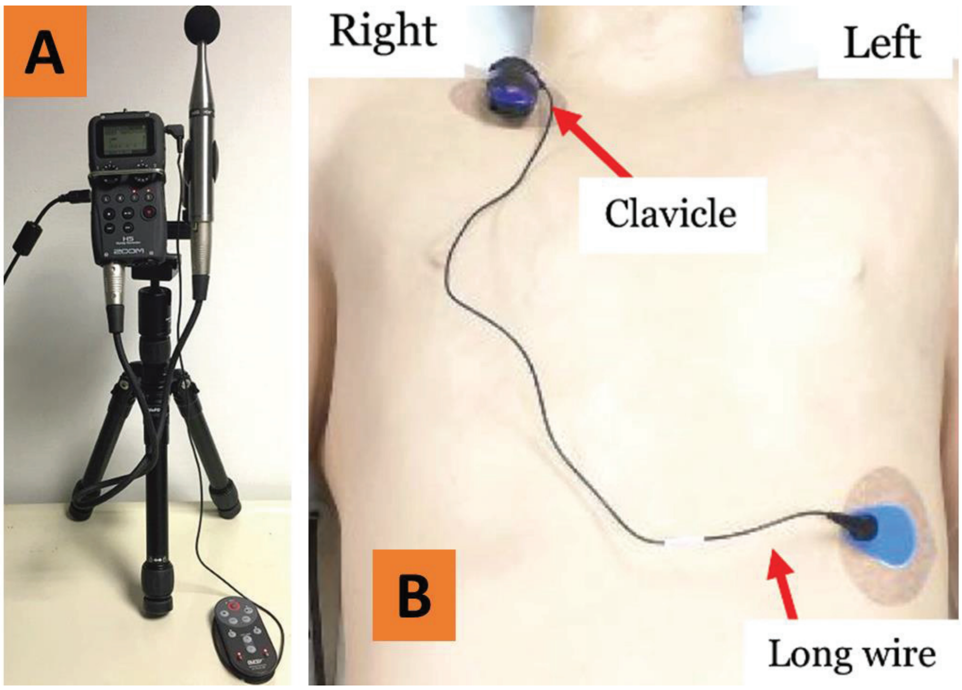

Figure 2: (A) Sound recorder (Zoom H5) and (B) Faros 90 actigraphy and heart rate monitor

From among the questionnaire respondents, 37 participants were initially recruited into the field study, with 34 participants completing five nights of unattended sleep measurements and 3 recruits dropping out before the study began (see Figure 2 for a description of the field study set-up).

3. RESULTS

Small prepaid cash incentives and sending follow-up reminder and survey waves were an effective method of improving response rates. Completed questionnaires were received from 407 respondents, who were broadly representative of their geographical region. Among these respondents, after adjustment for sociodemographic factors, calculated outdoor night-time (23:00-07:00) air traffic noise was significantly associated with self-reports of worse overall sleep quality, with those living in the 50<55 dB L_{Night} region reporting significantly worse sleep quality than those in the reference region (35<40 dB L_{Night}). Residents in the highest 3 levels of air traffic noise (≥45 dB) were significantly more likely to report that air traffic disturbed their sleep than those in the reference group, and those in the highest 2 levels (≥50 dB) were significantly more annoyed by air traffic noise than those in the reference group. Calculated outdoor night-time air traffic noise was also associated with trouble falling asleep within 30 minutes, greater difficulty staying awake during the day, and greater difficulty concentrating. Residents in areas exposed to higher levels of air traffic noise coped by closing the windows at night. We did not find a significant effect of nocturnal aircraft noise exposure on any of the investigated self-reported health outcomes.

Of the 34 participants completing five nights of unattended sleep measurements, data of sufficient quality and quantity to investigate the effects of aircraft noise on sleep were obtained, despite some data loss in the field study due to technical issues with the equipment and non-compliance among the participants. The technical issues were the main cause of data loss however, and non-compliance was low, with both physiologic and acoustic data collected by the participants in 87.6% of all study nights.

4. DISCUSSION

Concerning the primary objective of the study, evaluation of the feasibility of the study methodology, we demonstrated both the feasibility of recruiting field study participants by postal questionnaire in a larger, more nationally representative sample for future studies around multiple airports, and the feasibility of mailing equipment to participants to obtain unattended physiologic and acoustic measurement data. We also identified ways to maximize response rate to the recruitments survey.

Regarding the secondary objective of the study, investigating noise-induced effects on physiologic and self-reported sleep, a number of statistically significant outcomes were found, including associations between aircraft noise and physiologic and recalled awakenings. However, these findings are from a sample population of limited size, living close to a single airport. The findings of physiologic and self-reported effects of aircraft noise on sleep may not be representative of response among a demographically diverse national study population exposed to different patterns of nocturnal aircraft noise. A larger-scale study among such a population should be performed in the future, and the approach used in the present pilot study has been demonstrated to be feasible for this purpose.

5. CONCLUSIONS

In this study, we investigate feasibility of an unattended field study on the physiological effects of aircraft noise on sleep. Several ways to improve data quantity and quality were identified. Overall, the approach was found to be feasible.

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