Project 017 Pilot Study on Aircraft Noise and Sleep Disturbance

University of Pennsylvania

Project Lead Investigator

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- P.I.: Mathias Basner, Associate Professor
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- Period of Performance: October 01, 2017 to September 30, 2018
- Task(s):
    - ATL Pilot Sleep Study: Data analysis

Project Funding Level

The funding amount for this period was $135,306.00. The cost sharing requirement for this project was met by our international collaborators at the German Aerospace Center (DLR).

Investigation Team

- Principal Investigator: Mathias Basner
- Postdoctoral researcher: Michael Smith
- Research Assistant: Sarah Rocha

Project Overview

The long-term goal of this line of research is to derive exposure-response relationships for aircraft noise-induced sleep disturbance that are representative of the exposed U.S. population. As studies will have to investigate samples around multiple airports, it will not be possible to use polysomnography (i.e., simultaneous recording of the electroencephalogram, electromyogram, and electrooculogram) to monitor sleep, as this method requires trained personnel at the measurement site in the evening and in the morning and is thus too costly. An alternative methodology of using a single channel electrocardiogram (ECG) and actigraphy to monitor sleep has been examined. This methodology allows the investigation of larger subject samples at lower cost as individuals can be taught how to apply the electrodes themselves. Also, unlike polysomnography, awakenings can be identified automatically. As part of previous research, an algorithm for identifying EEG arousals (Basner, Griefahn, Müller et al., 2007) based on increases in heart rate was refined in order to only identify those arousals greater than or equal to 15 seconds in duration, which is the most agreed upon indicator of noise-induced sleep disturbance. High agreement between EEG visually scored arousals and arousals identified using the refined ECG based algorithm was obtained. The methodology of using ECG and actigraphy to monitor sleep has been implemented in two pilot field studies to evaluate the quality of data that can be obtained for unattended physiological and noise measurements. Based on lessons learned, the study protocol is being refined in order to inform the design and cost of a potential multi-airport study on the effects of noise on sleep.

Objectives

(1) Finish acquisition and analysis of acoustical and physiological data of the PHL study;
(2) Refine and, to the extent possible, automatize the methodology to identify aircraft noise events and maximum sound pressure levels in complex acoustical signals;
(3) Inform the design and cost of a potential large-scale field study on the effects of aircraft noise on sleep around multiple US airports based on lessons learned from the current field studies;
(4) Continue our collaboration with colleagues at the German Aerospace Center (DLR) to compare, combine, and publish findings from US and German field studies.

Research Approach

Based on lessons learned in the Philadelphia Sleep study, the methodology has been refined and a second pilot study is currently being conducted to evaluate its feasibility. The airport for this study was selected in consultation with the FAA and has relevant amounts of nighttime air traffic and a sufficient population from which to sample. To determine the sample regions around the airport, L_{Night} noise contours were provided by the FAA. Additionally, we calculated L_{Night} contours for 84 weekdays based on flight track data. For the study we have 10 sampling regions, 5 east and west of the airport of the following noise categories: < 40 dB (control region), 40-45 dB, 45-50 dB, 50-55 dB, and >55 dB L_{Night}.

To recruit participants for the study, brief surveys were mailed to randomly selected households within each of the 10 sampling frames. The primary purpose of the survey is determining the eligibility of individuals to take part in an in-home sleep study. The survey contains questions on the individual's health, sleep, and noise sensitivity. To increase the response rate to the recruitment survey, different incentives, such as a promised gift card and a pre-paid $2.00 were examined. Additionally, survey length and number of follow-up surveys were varied to determine their effect on response rate. The target number of completed surveys is 200 per 5dB noise category, for a total of 1000 surveys.

In the survey, participants indicate their interest in taking part in the in-home sleep study, which consists of 5 nights of unattended ECG and actigraphy measurements and indoor sound recordings. The equipment is mailed to the participants' homes and instruction manuals and videos on how to setup and use the equipment are provided. Mailing the equipment eliminated the need for staff in the field which significantly reduces the study cost. In addition, mailing the equipment may increase the response rate as staff does not enter the participants' homes. For enrolling in the in-home sleep study, participants received varying amounts of compensation. For survey mailing rounds 1-5, participants received $20 per night in which measurements were completed. Compensation was increased to $30 per night for mailing rounds 6-9, and to $40 per night for rounds 10-17. The purpose of increasing the compensation was to evaluate how response rate changes as compensation increases. This will help determine a cost-effective compensation for a future multiple airport study. The outcomes for this study are to determine the response rates for both the mail and in-home study, assess the feasibility of mailing equipment, and evaluate the quality of data that can be obtained.

Milestones

The following are milestones that were achieved during the past 12 months:
(1) Data collection for the second pilot sleep study was completed in 11/2017.
(2) Analysis of the acoustical and physiological data of the PHL study was completed.
(3) Analysis of the acoustical and survey data of the ATL study was completed.
(4) The physiologic and acoustical analysis methodology was refined.

Major Accomplishments

The approach for recruiting participants for in-home sleep measurements was refined. In collaboration with Dr. Uwe Müller from the German Aerospace Center, software to convert recorded audio signals to calibrated sound pressure levels was developed. Data collection for the second pilot study around ATL was completed, with 407 surveys received and 34 participants completing the in-home study of aircraft noise exposure and heart rate and body movements. Analysis of the surveys was completed, nighttime noise (L_{Night}) was significantly associated with worse overall sleep quality; L_{Night} also increased the likelihood of frequently having trouble sleeping due to nighttime awakenings, and having greater difficulty staying awake during the day. Residents in higher L_{Night} neighborhoods were more likely to report that their sleep was highly disturbed due to aircraft noise, and that they felt highly annoyed to aircraft noise over the past 12 months. The findings have been drafted into a manuscript that will be submitted to a peer reviewed journal in late 2018. Analysis of the ATL

acoustical and physiological data was ongoing at the end of the project period, the reason for a no-cost extension, and expected to be completed in November 2018.

Statistical analysis of the most effective approaches for receiving completed surveys and recruiting participants for the field study was completed. Personalizing the address, enclosing a $2 cash incentive with initial questionnaire mailing and repeated follow-up mailings were effective at increasing response rate. Although these approaches were more expensive than other approaches in terms of per household mailed, the higher response rates meant that they were more cost-effective overall for obtaining an equivalent number of responses. Although no effect of the different strategies on the likelihood that respondents would eventually participate in the field study was observed, pre-issued cash incentives and sending follow-up waves would maximize the numbers of people from which to recruit, and may be an effective strategy for improving recruitment into the field studies. The total cost to receive a completed survey was around $30 for the most cost-effective approaches. The total cost to recruit a single participant into the field study was around $400 for the most cost-effective approaches.

Publications

Basner, M., Clark, C., Hansell, A., Hileman, J.I., Janssen, S., Shepherd, K., Sparrow, V.: Aviation noise impacts: state of the science. Noise and Health 19(87): 41-50, 2017.
Basner, M., McGuire, S.: Pilot study examining the effects of aircraft noise on sleep in communities near Philadelphia International airport. Presentation at the 12th ICBEN Congress on Noise as a Public Health Problem, Zurich, Switzerland, June 18-22, 2017.
Müller, U., Elmenhorst, E.-M., Mendolia, F., Quehl, J., Basner, M., McGuire, S., Aeschbach, D.: A comparison of the effects of night time air traffic noise on sleep at Cologne/Bonn and Frankfurt Airport after the night flight ban. Presentation at the 12th ICBEN Congress on Noise as a Public Health Problem, Zurich, Switzerland, June 18-22, 2017.
McGuire, S., Müller, U., Elmenhorst, E.-M., Mendolia, F., Aeschbach, D., Basner, M.: Cross-country comparison of aircraft noise-induced sleep disturbance. Poster at the 12th ICBEN Congress on Noise as a Public Health Problem, Zurich, Switzerland, June 18-22, 2017.
McGuire, S., Basner, M.: Development of a methodology for field studies on the effects of aircraft noise on sleep. Presentation at the 173rd Meeting of the Acoustical Society of America and the 8th Forum Acusticum, Boston, MA, June 25-29, 2017.
Smith, M., Witte, M., Rocha, S., Basner, M.: Effectiveness of incentives and follow-up on increasing survey response rates and participation in field studies. Manuscript currently under FAA project manager review, to be submitted to Public Opinion Quarterly.
Basner, M., Witte, M., McGuire, S.: Aircraft noise effects on sleep – results of a pilot study near Philadelphia International Airport. Manuscript currently under FAA project manager review, to be submitted to the International Journal of Environmental Research and Public Health.
Rocha, S., Witte, M., Smith, M., Basner, M.: Survey results from a pilot sleep study near Atlanta international airport. Manuscript to be submitted to International Journal of Environmental Research and Public Health, in preparation.

Outreach Efforts

None

Awards

None

Student Involvement

None

Plans for Next Period

The analyses of acoustic and physiological data from the ATL pilot study will be finalized. We will continue our collaboration with colleagues at the German Aerospace Center (DLR) to compare findings from US and German field studies and to prepare joint publications.

References

Basner M, Griefahn B, Müller U, Plath G, Samel A. An ECG-based algorithm for the automatic identification of autonomic activations associated with cortical arousal. Sleep 2007; 30(10):1349-61.