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, 2016 to September 30, 2017
- Task(s):
    - ATL Pilot Sleep Study: Data collection and analysis

Project Funding Level

The funding amount for this period was $266,001.00. 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
- Co-Investigator: Sarah McGuire
- Research Assistants: Maryam Witte, Sarah Rocha, Anjana Kallarackal

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 to sample from. 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 target enrollment for the in-home study is 40 per 5 dB noise category, for a total of 200 participants. 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 began 9/2016 and will be finalized in 11/2017.

Major Accomplishments

The approach for recruiting participants for in-home sleep measurements was refined. This included determining the survey incentive, length of survey, and number of follow-up mailings that maximized the response rate. We have obtained 403 surveys and have completed in-home sleep measurements for 34 participants. The option of providing a hair sample was added to the protocol of the in-home study. The samples will be used to determine cortisol levels, which are a measure of long-term stress. Instructions for the hair collection protocol have been created and all staff has been trained. Data collection is ongoing but will end in 11/2017.

Publications

McGuire, S., Witte, M., Kallarackal, A., Basner, M.: Pilot study examining the effects of aircraft noise on sleep in communities near Philadelphia International airport. Poster at the 31st Anniversary Meeting of the Associated Professional Sleep Societies, Boston, June 11-15, 2016.

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.

Outreach Efforts

None

Awards

None

Student Involvement

None

Plans for Next Period

Data collection for the in-home sleep study will continue and end in 11/2017. No more surveys will be mailed. The main focus of the next period is to analyze the sound recordings and physiological data of the ATL study. For this analysis we plan to refine and automatize the methodology of identifying aircraft noise events and maximum sound pressure levels in the recordings. The identification of aircraft noise events can be challenging based on indoor sound measurements only due to masking of other noise events (e.g., air conditioning system, snoring). We will continue our collaboration with colleagues at the German Aerospace Center (DLR) to compare findings from US and German field studies

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.