



Project 003 Cardiovascular Disease and Aircraft Noise Exposure

Boston University

Project Lead Investigator

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University Participants

Boston University (BU)

- P.I.(s): Jonathan Levy (University PI); Junenette Peters (Project PI)
- FAA Award Number: 13-C-AJFE-BU-002;
- Period of Performance: October 1, 2017 to September 30, 2018

Tasks:

1. Assign aircraft noise exposures over time to geocoded participant addresses for new cohorts - Nurses' Health Study (NHS), NHSII, NHS3, Health Professional Follow-up Studies (HPFS), and HPFS2.
2. Link aircraft noise exposures to participant data for NHS, NHSII, NHS3, HPFS, and HPFS2.
3. Determine the numbers of cardiovascular disease (CVD)-related outcomes of interest available in NHS, NHSII, and HPFS participants living near airports.
4. Develop and execute models for estimating CVD health risks associated with aircraft noise exposure.

Project Funding Level

Total Funding \$340,000

Matching: \$294,867

Source of Matching: Non-federal donors to the NHS and HPFS cohorts

Investigation Team

Junenette Peters, PI, Boston University

Dr. Peters is responsible for directing all aspects of the proposed study, including study coordination, design and analysis plans, and organizing co-investigator meetings.

Jonathan Levy, Boston University

Dr. Levy will participate in the noise exposure assessment effort and provide expertise in the area of predictive modeling and air pollution.

Francine Laden and Jamie Hart, Harvard University

Dr. Laden is our NHS and HPFS sponsor for this ancillary study. Dr. Jamie Hart's will assign aircraft noise exposures to cohorts' participant geocoded address coordinates. Dr. Laden and Dr. Hart will also assist with documentation of data from the NHS and HPFS based on previous experience working on air pollution and chronic disease outcomes research in these cohorts.



Project Overview

Aircraft noise is a considerable source of stress among near-airport communities. Exposure has been associated with sleep disturbance, physiological responses and psychological reactions, with corresponding effects on blood pressure. However, the extent to which aircraft noise increases the risk of cardiovascular disease (CVD) has not been fully elucidated. Likewise, the role of CVD risk factors in mediating an association between noise and CVD has not been assessed. Additionally, exposure assessment that includes time-varying and spatially resolved noise exposures has not been systematically incorporated into previous epidemiological studies, making it key to receive aircraft noise data over multiple years. FAA PARTNER 44 and ASCENT 03 projects provided the pilot data and collaborations necessary to successfully compete for National Institute of Health (NIH) funding to evaluate noise effects on cardiovascular outcomes in the longitudinal Women's Health Initiative (WHI) cohorts. This study proposes to extend ongoing efforts in the WHI and evaluate the effects of aircraft noise exposure on cardiovascular disease in both women and men in the longitudinal Nurses' Health Studies (NHS, NHSII, and NHS3) and companion Health Professional Follow-up Study (HPFS and HPFS2) cohorts. These studies began with the original cohort (NHS) in 1976 and is currently recruiting the third generation (NHS3), with over 330,000 total participants.

The proposed scope of this research effort would involve multiple years, with activities within Phase I providing the foundation for future activities. The objectives for this year include: 1) Determining noise exposure estimates for study participants; 2) Linking noise exposure estimates to participant data on outcomes (health effects) and other risk factors; 3) Developing and executing models to evaluate cardiovascular effect(s) of noise.

Tasks based on receiving noise data for 90 airports over time in multiple metrics:

- Initially projected timeline for receiving data for 2000, 2005 and 2010 – March 2015
- Also negotiated for noise data for additional years (1995 and 2015)

However, data was modeled by two facilities (Wyle and Volpe) using different methods and assumptions. Data for 37 airports needed to be rerun to harmonize data.

- Received data from rerun of 37 airport for key metrics – October 2017.
- Received data from rerun for remaining metrics – November 2017.
- Performed quality assurance/quality control and requested corrections.
- Received final data for all metrics – August 2018.

Task 1- Assign Aircraft Noise Exposures Over Time to Geocoded Participant Addresses

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Objective

To intersect geocoded addresses available from 1995 to 2015 with noise surfaces obtained.

Research Approach

We will intersect geocoded addresses with noise contours available from 1995 to 2015. Given the longitudinal nature of this study, noise exposures will be assigned reflecting specific residential addresses over time based on participant address histories. We will estimate the percent of participants across noise exposure categories (e.g., DNL > 55 dB) and assess overall trends in participant noise exposure levels over time.

Milestone

(Dependent on receiving noise data – originally projected for March 2015; actual date of final receipt of August 2018)

- Assign aircraft noise exposures – November 2016

Major Accomplishments

- Collaborated with Volpe to develop a final aircraft noise modeling documentation (metadata).



- Received aircraft noise data for airports for the years 1995, 2000, 2005, 2010, 2015. Metrics received include Day-Night Average Sound Level (DNL), Equivalent Sound Level (Leq) Day and Leq Night, Time above Threshold (TA) 65 dB and TA 85 dB.
- Performed quality assurance/quality control for noise contours for all 90 airports.
- Received final corrected data for 90 airports and 5 metrics and 5 years.
- Processed DNL data.
- Estimated noise exposure in DNL for participants of NHS, NHSII, HPFS.
- Estimated the number of people exposed to aircraft noise for the NHS and NHSII cohorts (Figure 1) based on those free of hypertension (see Table 2).

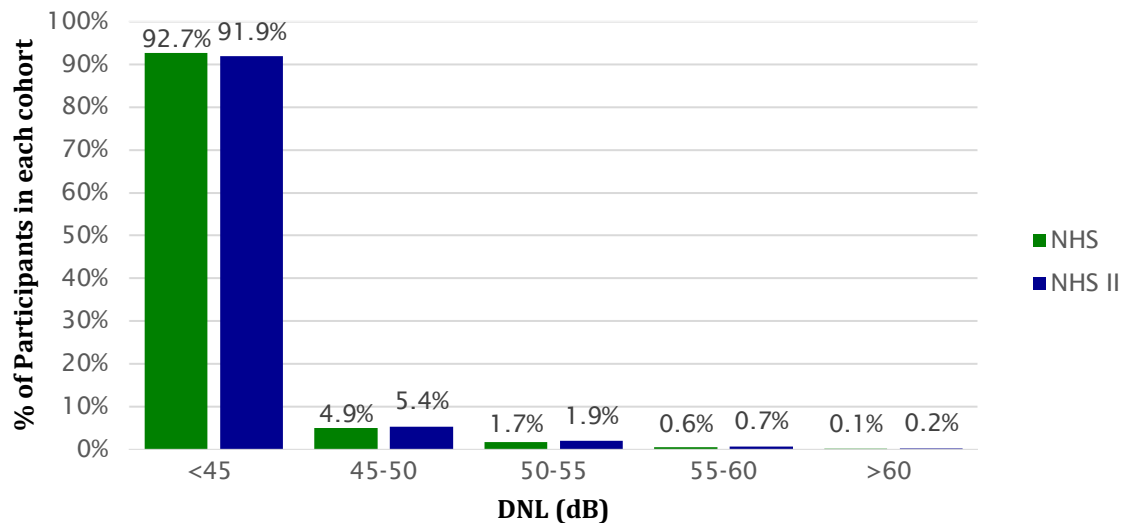


Figure 1: Distribution of aircraft noise (DNL) in those free of hypertension at baseline (1995)

Task 2- Link Aircraft Noise Exposures to Participant Data for NHS, NHSII, NHS3, HPFS, and HPFS2

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Objective

To link with the individual level information in NHS and HPFS.

Research Approach

We will link information with the wealth of individual level information on socio-demographics (e.g., age, race/ethnicity, education); lifestyle factors (e.g. physical activity/exercise, diet, smoking, alcohol consumption); and relevant outcomes (e.g., hearing and hearing loss, sleep disturbance, diabetes, CVD and CVD mortality).

Milestone

Link aircraft noise exposures to individual data for all cohorts – December 2016

Major Accomplishments

Linked aircraft noise exposures in DNL to individual cohort data for NHS and NHSII (see Tables 1 and 2).

Task 3- Determine the Numbers of CVD-Related Outcomes of Interest Available in NHS, NHSII, and HPFS Participants Living Near Airports

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Objective

To identify all cases of overall and cause-specific incident cardiovascular, cardiovascular mortality and incident hypertension.

Research Approach

We will identify all cases of overall and cause-specific incident CVD, CVD mortality, and incident hypertension among individuals in the NHS, NHSII, and HPFS living within the 45 dB contours. These cohorts have been followed over a long enough period (over two to four decades) to observe health outcomes and participants are of an age when they are at risk for CVD.

Milestones

Determine the number of cardiovascular-related outcomes among those living near airports - January 2016

Determine the number of participants at risk for cardiovascular disease (free of CVD at baseline/earliest time with available noise data [1995]).

Major Accomplishments

Determined the number of cohort participants alive and free of CVD at baseline (1995). Preliminary characteristics of participants provided in Table 1.

Table 1. Characteristics of participants alive and free of CVD at baseline (1995)

Characteristics	NHS	NHSII	HPFS
Number of Participants	96,000	115,000	50,000
	Mean ± SD or %		
Age (years)	68.6 ± 7.3	46.6 ± 7.0	63.8 ± 10.2
Body mass index (kg/m ²)	25.6 ± 7.5	21.2 ± 3.2	26.6 ± 11.5
Race (%)			
Black	2	2	6
White	94	96	91
Other/Multiple races	6	2	3
Smoking Status (%)			
Never	45	64	40
Former	45	25	41
Current	11	9	6
Family History of MI	32	22	13

Determined the number of cohort participants alive and free of hypertension (self-reported) at baseline (1995). Characteristics provided in Table 2.

- Study Period
 - NHS: 1994-2007
 - NHS II: 1995-2006
- Exclusion Criteria
 - No diagnosed hypertension at the entrance into our study
 - No missing noise or air pollution data



Table 2. Characteristics of participants alive and free of hypertension at baseline (1995)

Characteristics	NHS	NHSII
Number of Participants	61,876	94,588
	Mean ± SD or %	
Age (years)	59 ± 7	40 ± 5
Race - White (%)	95	93
Post-Menopausal (%)	88	7
Family History of Hypertension (%)	36	49
Smoking Status (%)		
Never	43	65
Former	41	24
Current	15	11
Census Tract Medium Income (USD in \$1000)	65 ± 26	64 ± 24

Task 4- Develop and Execute Models for Estimating CVD Risk Associated with Noise Exposure in NHS, NHSII, and HPFS

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Objective

To develop appropriate measures to evaluate the effects of aircraft noise on cardiovascular outcomes.

Research Approach

The team will develop hazard models for estimating time varying CVD risk associated with noise exposure in the vicinity of each airport. We will also explore methods to account for clustering and spatial correlation between individuals living near each airport. We will then conduct epidemiological analyses to estimate the health effects of noise exposure on each CVD outcome controlling for other risk factors thought to be related to CVD

Milestones

Develop models for estimating cardiovascular health risks associated with aircraft noise exposure – January 2016

Perform analysis of cardiovascular health risks associated with aircraft noise exposure – June 2016

Major Accomplishments

- Developed model for estimating hypertension associated with aircraft noise exposure using DNL.
 - Using time-varying Cox hazards model (allows for changes in exposure and risk factors over time)
 - dichotomizing self-reported hypertension (yes/no)
 - dichotomizing noise exposure (DNL >44, >50, >55, and >60 dB)
 - adjusting for: medication use, race, region, smoking history, area-level income, area-level housing value, air pollution, BMI, alcohol consumption, diet, menopausal status, family history of hypertension, physical activity, latitude, diabetes status
- Performed initial analysis of association of aircraft noise (DNL) and the risk of hypertension.
- Submitted abstract titled ‘Time-varying aircraft noise exposure and incident hypertension in the Nurses’ Health Study’ to professional society conference (joint meeting of the International Society of Exposure Science [ISES] / International Society for Environmental Epidemiology [ISEE]).
- Presented preliminary analysis at the ISES/ISEE joint meeting.
 - Preliminary Results: Incidence of hypertension is increased with increased DNL, but statistically non-significant



Publications

- Peters JL, Zevitas CD, Redline S, Hastings A, Sizov N, Hart JE, Levy JI, Roof CJ, Wellenius GA. Aviation noise and cardiovascular health in the United States: a review of the evidence and recommendations for research direction, *Current Epidemiology Reports* 2018; 5(2):140-152. doi.org/10.1007/s40471-018-0151-2.

Outreach Efforts

Developed and submitted abstracts and presented at professional conference (joint meeting ISES/ISEE).

- Nguyen DD, Levy J, Hart JE, VoPham T, Simon MC, Malwitz A, Laden F, Peters JL. Characterizing temporal trends in aviation noise surrounding U.S. airports, ISES/ISEE 2018 Annual Joint Meeting, August 2018 (oral).
- Simon MC, Hart JE, Levy J, VoPham T, Lane KJ, Fabian MP, Nguyen DD, Laden F, Peters JL. Sociodemographic patterns of exposure to civil aircraft noise, ISES/ISEE 2018 Annual Joint Meeting, August 2018 (poster).
- Kim CS, Hart JE, Levy JI, VoPham TM, Simon MC, Nguyen DD, Malwitz A, Laden F, Peters JL. Time-varying aircraft noise exposure and incident hypertension in the Nurses' Health Study, ISES/ISEE 2018 Annual Joint Meeting, August 2018 (oral).

Awards

None

Student Involvement

Chloe Kim (doctoral candidate) dissertation includes aspects of Task 4 – developing and executing models on noise and hypertension risk. Chloe presented on 'Time-varying aircraft noise exposure and incident hypertension in the Nurses' Health Study' at the joint meeting of ISES/ISEE.

Daniel Nguyen (doctoral candidate) presented on 'Characterizing temporal trends in aviation noise surrounding U.S. airports' at the joint meeting of ISES/ISEE.

Plans for Next Period

(TBD [*awaiting funding*] to September 30, 2019)

- Assign noise exposure estimates to participants for additional metrics (Leq Day and Leq Night and TA 65dB and TA 85 dB).
- Finalize models estimating CVD-related risks factors (e.g., hypertension) associated with aircraft noise exposure and develop manuscript for publication in peer-reviewed journal.
 - Perform analysis using DNL for HPFS.
 - Perform analysis using Leq Night for all cohorts.
 - Perform meta-analysis combining the results for all three cohorts – NHS, NHSII, and HPFS.
- Execute models estimating risk of CVD associated with aircraft noise exposure.
- Develop abstracts for presentation at professional conferences.
- Determine the number of newly recruited participants (NHS3) residing near airports from whom survey questions or measurements of noise and sleep disturbance may be obtained.
- Develop suite of survey questions on built environment and noise perception.