Cardiovascular Disease and Airport Noise Exposure
Project 03

Project manager: N. Sizov, FAA
Lead investigator: J. Peters, Boston University School of Public Health

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Alexandria, VA

ASCENT
AVIATION SUSTAINABILITY CENTER

Overview

Original ASCENT 3 Project Linked to AEE Roadmap

Health Impacts of Aviation

- **Goal:** To evaluate the relationship between aircraft noise exposure and cardiovascular health in existing national longitudinal health cohorts

New Linked to FAA Reauthorization Section 189

Health and Economic Impacts of Aviation

- **Goal 1 (Health Impacts):** To evaluate the relationship between aircraft noise exposure and health including hypertension and sleep disturbance in existing health cohorts

- **Goal 2 (Economic Impacts):** To assess economic benefits or harm to businesses underneath regular flight paths at selected U.S. airports

Health Impacts - *Objectives*

Objective:
Assess *health* impacts of noise
1. *Cardiovascular disease (CVD)*
2. *Sleep outcomes*

Continuation of Previous Work

- **Cardiovascular Disease (CVD)** related to aircraft noise exposure
  - Nurses Health Studies (NHS orig. and II)
  - Noise metrics
    Day-night average sound level (DNL), Night equivalent sound level (Lnight), Time above threshold (TA) dB 65 and 85

New Work (Section 189)

- **Sleep Disturbance** related to aircraft noise exposure
  - NHS and Growing Up Today Study Women's Health Initiative, WHISPER
  - Noise metrics
    DNL, Lnight, TA and Flight paths

Health Impacts – *Project Outline*

Summer / Fall 2019

1 Complete CVD Analyses in Process
(Ascent 3)

- Analysis of trends of aircraft noise exposures
- Sociodemographic patterning of noise exposures
- Analysis of aircraft noise (DNL and Lnight) and hypertension

2 Perform CVD Phase II Analysis
(Ascent 3)

- Analytical approaches and analysis of relationship of aircraft noise and CVD
- Analytical approaches and analysis of relationship of additional metrics of aircraft noise and health outcomes.

**+ Develop Analytical Approach & Sleep Analysis**
(Section 189)

- Assessment of potential approaches for analysis and appropriateness of sleep quality data.
- Analysis of annual average aircraft noise exposure with general sleep length and quality (NHS).
- Analysis of living under flight paths with sleep disturbance measures (WHISPER).

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Spring 2022

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Health Impact – *U.S. Noise Trends*

Exposure Area

- Found non-monotonic trends in mean exposed areas for ≥55 and ≥65 dB DNL over time that peaked in 2000.
  - Exposed areas largest in the Midwest region from 2000 to 2005.
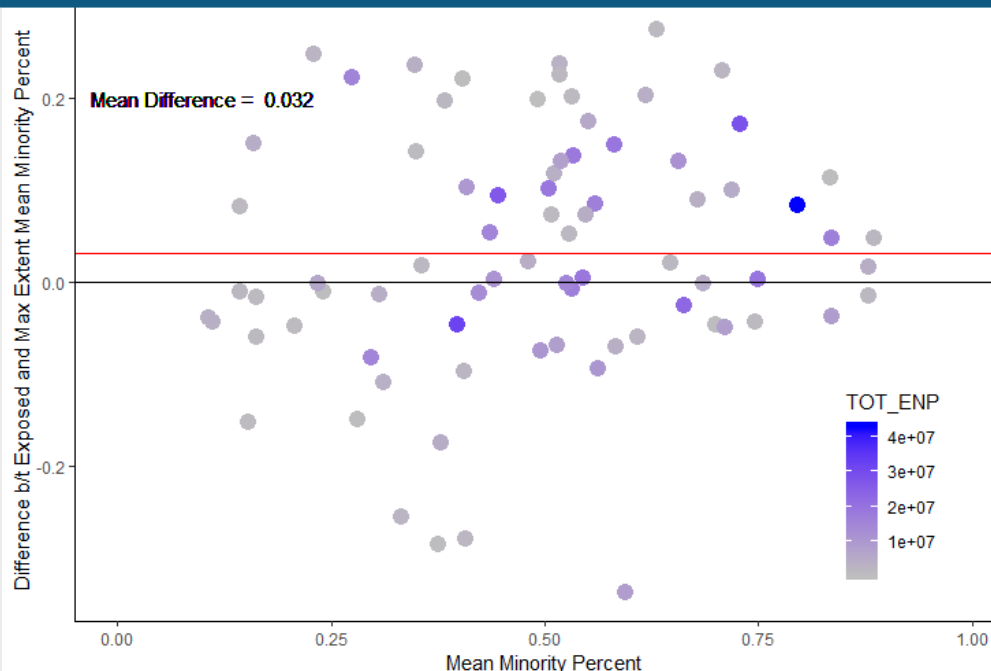 - Only West region increased from 2010 to 2015.

LS-Means for year*REGION
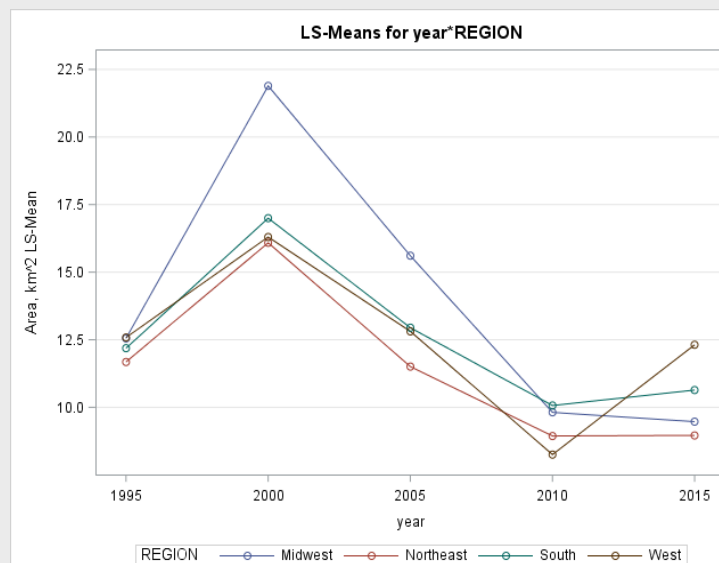
Exposed Population

* per thousand	DNL 55 dBA			DNL 65 dBA		
	Population in 2000	Population in 2010	Δ	Population in 2000	Population in 2010	Δ
All Region	8352	4595	-45%	731	309	-58%
Midwest	2040	892	-56%	160	51	-68%
Northeast	2493	1381	-45%	198	86	-56%
South	2164	1359	-37%	191	68	-64%
West	1655	963	-42%	182	103	-43%

Health Impact Results -
U.S. Sociodemographic Patterning

Race/Ethnicity Patterning - Univariate	Overall Sociodemographic Patterning - Multivariate	

DNL Variable	55-dB Threshold	
	Odds Ratio	95% CI
% Black	1.003	(1.002, 1.005)
% Asian	1.006	(1.003, 1.009)
% Hispanic	1.006	(1.004, 1.008)
% Other	0.993	(0.985, 1.001)
Distance to Airport (km)	0.781	(0.772, 0.790)
% <9thGrade	1.016	(1.011, 1.022)
% 9th-<College Degree	1.007	(1.004, 1.010)
% HH <$25k	0.988	(0.985, 0.992)
% HH $25k-$100k	0.994	(0.991, 0.998)
Region (ref: NE)		
Midwest	1.539	(1.376, 1.720)
South	1.073	(0.972, 1.184)
West	0.828	(0.744, 0.920)

- Exposure patterns vary by airport.
- Low economic status and minorities tend to have higher aircraft noise exposure.

Health Impacts - *Study Populations*

Nurses' Health Study (Original)

- Began 1976, includes 121,701 women, registered nurses living in 11 populous states at enrollment
- At noise study baseline (1995) - 96,000 alive and free of CVD

Nurses' Health Study II

- Began 1989, includes 116,430 women, registered nurses living in 14 populous states at enrollment
- At noise study baseline (1995) - 115,000 alive and free of CVD

WHISPER Study

- Women's Health Initiative (WHI) sub-study of sleep disordered breathing and CVD, cancer and cognitive decline
- Began 2017, includes 5000 older women from the ongoing WHI Extension Study
- Sleep assessment using sensitive wrist-worn devices to measure blood oxygen desaturation (oximetry) and motion (actigraphy)

Health Impacts – *Hypertension*

Participants – NHS & NHS II

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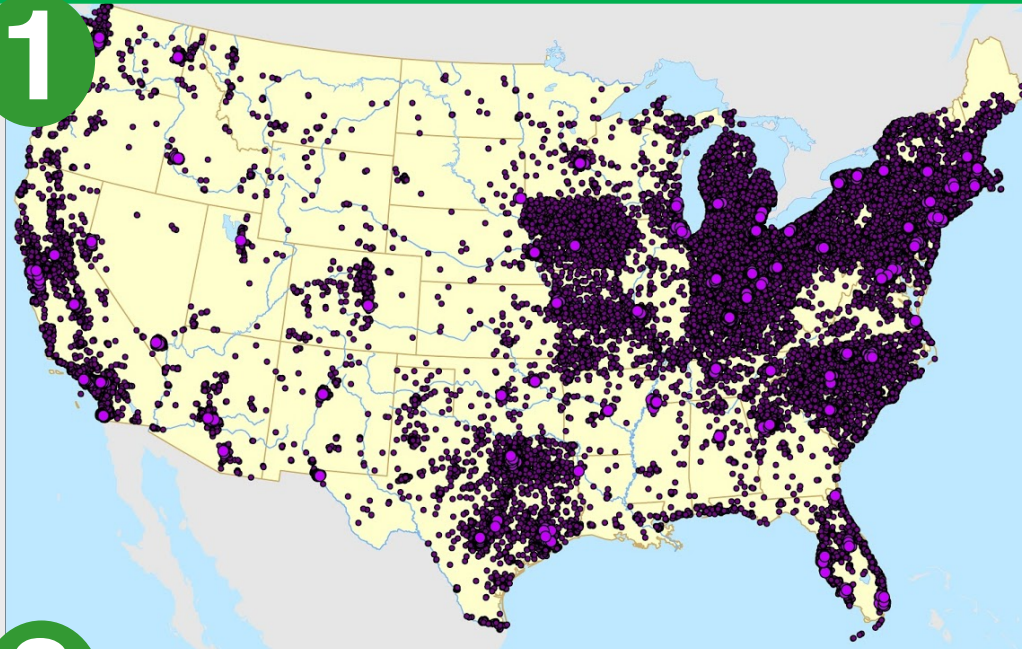
2 Number at Risk at Baseline

NHS (1994): 61,879
NHS II (1995): 94,592

3 Noise Exposure Distribution in NHS & NHS II for Follow-Up

Cohort	DNL>44 dB(A) N (%)	DNL>55 dB(A) N (%)	DNL>65 dB(A) N (%)
NHS	2,624 (6.03)	246 (0.60)	9 (0.02)
NHS II	5,720 (7.48)	578 (0.75)	24 (0.03)

Participant - Characteristics

Characteristic	DNL <= 55 dB(A) Mean (SD) or %	DNL > 55 dB(A) Mean (SD) or %
	NHS II (1995)	
Age, (years)	40.1 (4.63)	39.9 (4.57)
Body mass index (kg/m^2)	25.3 (5.43)	25.5 (5.69)
DASH score	23.9 (5.09)	23.4 (5.03)
Physical activity (MET hr/week)	18.7 (23.0)	19.3 (26.03)
Alcohol consumption (g/day)	3.50 (6.59)	3.61 (6.42)
Census-tract median income (USD)	64,300 (23,700)	62,000 (19,500)
Census-tract median home value (USD)	164,000 (123,000)	198,000 (97,100)
PM$_{2.5}$ (µg/m^3)	9.79 (4.07)	10.8 (3.48)
PM$_{2.5-10}$ (µg/m3)	14.0 (2.97)	15.0 (2.58)
Caucasian	93.8	81.3
Diabetes (yes)	0.99	1.66
Hypercholesterolemia (yes)	9.43	8.06
Statin use (yes)	3.76	3.96
Post-menopause (yes)	11.3	9.72
Hearing loss (yes)	2.34	2.3
Current smoking status (yes)	11.2	13.7
Family history of hypertension (yes)	49.3	50.8

Health Impact Results- *Hypertension*

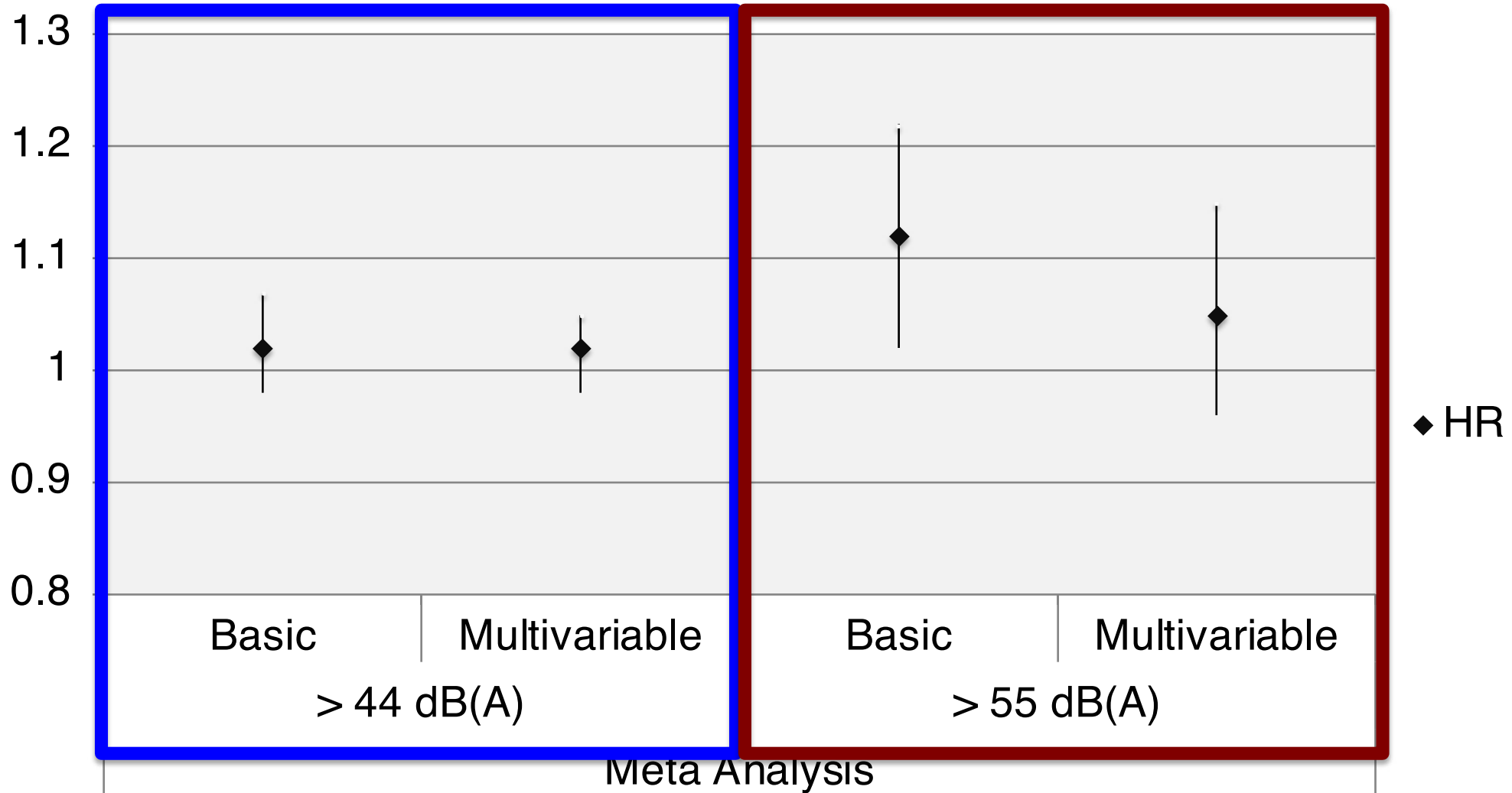## Statistical Analyses –Hypertension Risk NHS II
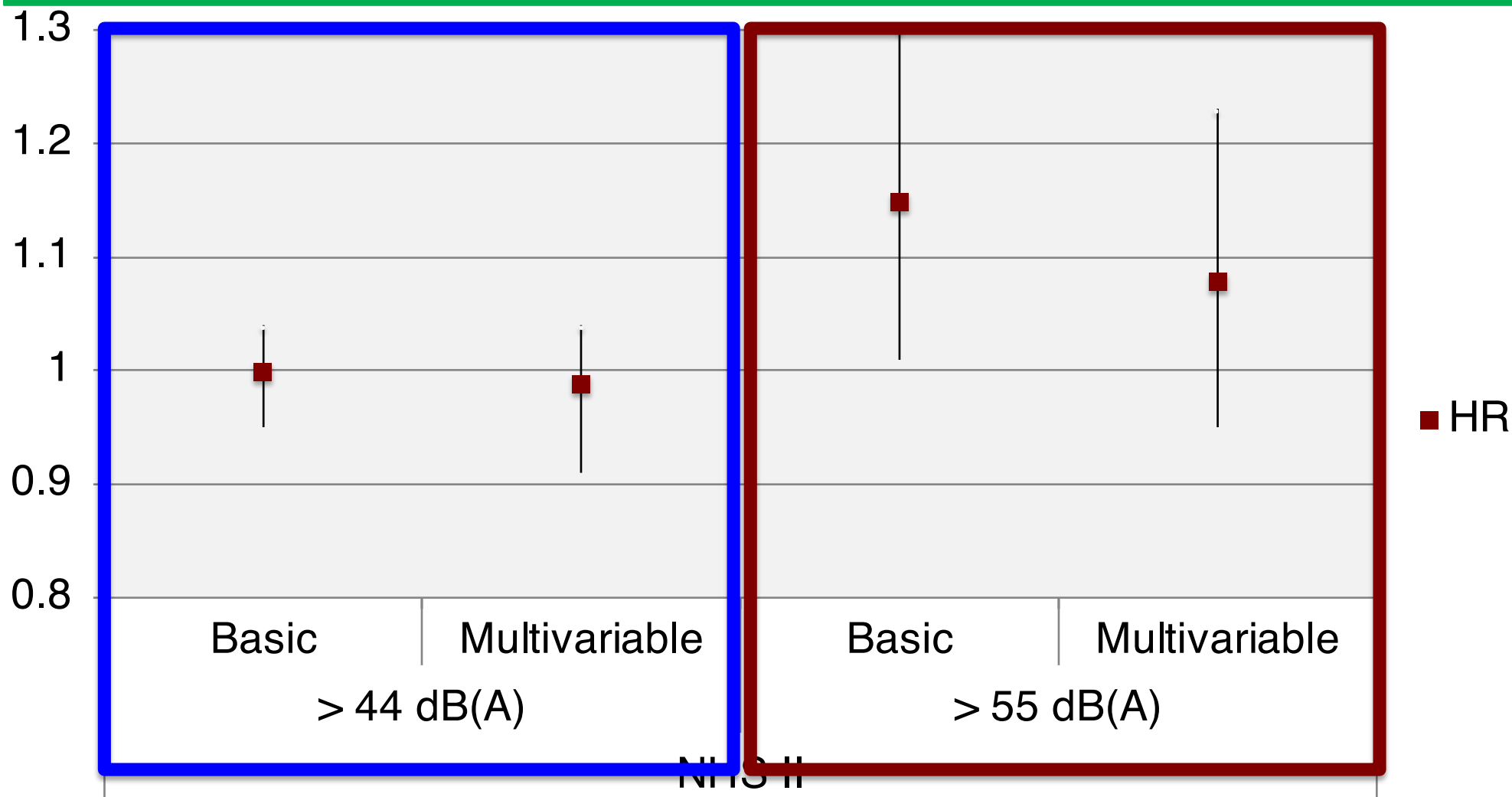
Basic model: Adjusted for age and calendar year
Multivariable model: Further adjusted for BMI, diet, physical activity, alcohol consumption, race, current smoking status, NSAID use, statin use, diabetes status, hearing problem, educational attainment

Health Impact Results- *Hypertension*

Statistical Analyses –Hypertension Risk Combined

Basic model: Adjusted for age and calendar year
Multivariable model: Further adjusted for BMI, diet, physical activity, alcohol consumption, race, current smoking status, NSAID use, statin use, diabetes status, hearing problem, educational attainment
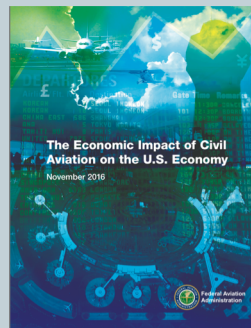
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Economic Impacts - *Motivation*

Existing work

Noise impacts

- **Human health impacts** related to aircraft noise *(ASCENT 3)*
- Different **exposure metrics** for aircraft noise *(ASCENT 23 & 44)*

+

Economic impacts

FAA associates **U.S. aviation** with economic impacts *(year 2014)*:

- *Output* at 5.1 % of U.S. GDP
- 10.6 million *jobs*

Source: FAA (2016): The economic Impact of Civil Aviation on the U.S. Economy

Objective:
Assess *economic impacts* to businesses located underneath flight paths, driven by

1. *Positive impacts* of air transport industry and air transport connectivity
2. *Negative impacts* on productivity and revenue from overflights and noise

Economic Impacts – *Framework*

Noise impacts on businesses

vs.

- Productivity of employees
- Location choice of clients
- Location choice of businesses
- …

Economic impacts of aviation

Demand-side impacts

*Demand-side impacts quantify contribution of aviation sector to **macroeconomic demand** (i.e. for all goods and services)*

Catalytic impacts

*Impacts resulting from **use of aviation** as **input factor** to other economic production processes*

Economic option value

Value from availability of aviation services, but not related to use of services

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Direct impact

Economic activity of sector itself

Indirect impact

Economic activity in supply chain of the aviation sector

Induced impact

Economic activity driven by consumption of direct & indirect employees

Tourism economy

Aviation acts as "input factor" for production of goods and services causing *forward linkages* (enabling impacts)

Multiplier effect

Employment, GVA/GDP, Income ← – – – – –

GDP, Productivity, Employment, Trade, FDI, Patents

Location choice

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Economic Impacts – *Project Outline*

Summer / Fall 2019	**1** **Literature review**	Review and structure the existing scientific literature on economic impacts of aviation

2 **Develop empirical approach**

- *Goal:*
  Explain economic outcomes (e.g. employment, revenue) as a function of aircraft noise exposure and airport amenity

- *Anticipated identification approach:*
  Introduction of RNAV procedures as a natural experiment

Flight tracks BOS, 2010

Flight tracks BOS, 2017
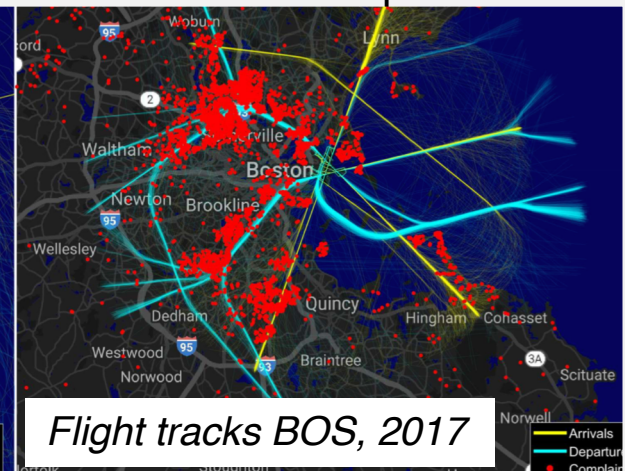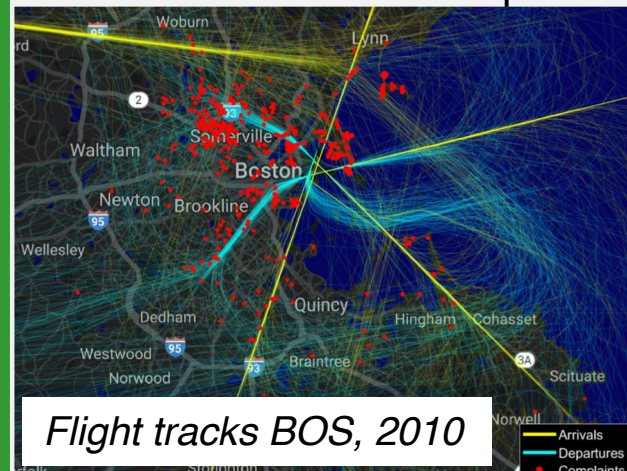
Hansman et al., 2018

3 **Data collection**

- High-resolution data for outcome and control variables (e.g. from Economic Census)
- Obtain or model noise exposure data, incl. DNL, N_{above}

Spring 2022

4 **Run analysis**

Summary

Next Steps

- Linking all noise exposure metrics with cohort data
- Performing detailed analysis for all three cohorts (NHS, NHSII, HPFS) to evaluate associations between noise and health

Key Challenges/Barriers

- Dealing with exposure misclassification related to non-modeled aircraft exposure – e.g., living near large military base.
  - Have proxy measures for 750 additional airports and military bases. including location and enplanements (later only for non-military and combined-use airports).
- Determining correct modeling approach to deal with 'zero-inflated' data (i.e., ~large proportion of non-exposed, ~90% of participants)
  - Multiple imputation incorporating proxy measures?

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.

Contributors

- BUSPH: Junenette Peters, Jonathan Levy, Matthew Simon (post doc), Chloe Kim (student), Daniel Nguyen (student)
- Harvard: Francine Laden, Jaime Hart, Susan Redline
- MIT: R. John Hansman, Florian Allroggen, Carlson Bullock (student)

New in green

References

- Babisch W, Kim R. Environmental Noise and Cardiovascular Disease. In: WHO European Centre for Environmental Health, ed. *Burden of disease from environmental noise: Quantification of healthy life years lost in Europe*. Copenhagen: World Health Organization; 2011:15-44.

- Colditz GA. Nurses' Health Study: demonstrating the impact of research, and adapting new measures and approaches to increase relevance and effect of cohort studies. Public Health Res Pract. 2016;26(3):e2631628.

- Colditz GA, Manson JE, Hankinson SE. The Nurses' Health Study: 20-year contribution to the understanding of health among women. J Women's Health 1997;6:49-62.

- Correia AW, Peters JL, Levy JI, Melly S, Dominici F. Residential exposure to aircraft noise and hospital admissions for cardiovascular diseases: multi-airport retrospective study. BMJ. 2013;347:f5561.

- Hansell AL, Blangiardo M, Fortunato L, et al. Aircraft noise and cardiovascular disease near Heathrow airport in London: small area study. BMJ 2013;347:f5432.

Collaboration

- ## Between Noise PIs
  – Pennsylvania State University with NIH funding

- ## Other
  – Volpe Transportation Center
  – Project 23 and 44 on noise exposure metrics
  – *Potential:* Project 17 (Aircraft Noise and Sleep Disturbance)