

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

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Overview

ASCENT 3 Project Linked to AEE Roadmap and 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) and
 - Night equivalent sound level (L_{night})

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 and L_{night}

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).

3

Spring
2022

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

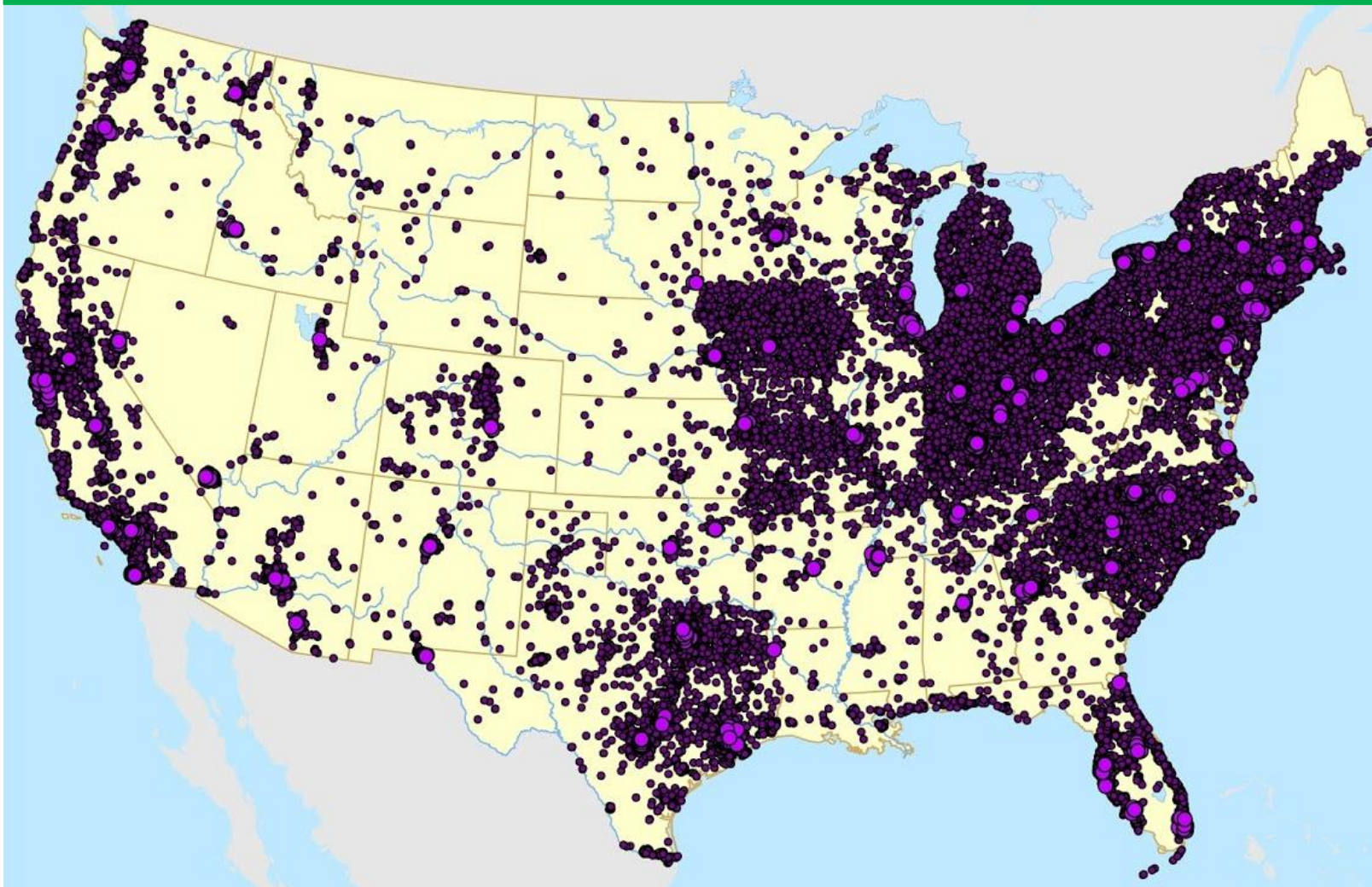
Nurses' Health Study II

- 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)

Participants – NHS & NHS II



Health Impacts – *Hypertension* (*Update*)

Objective:
Assess *health*
impacts of noise
- *hypertension*

Completed

- Analysis of noise (DNL) and hypertension
- Manuscript preparation
- Presentation of results:
 - International Society of Environmental Epidemiology Conference(2018)
 - Aviation Noise and Emission Symposium (2020)

To do

- Account for spatial correlation
- Prepare Lnight metrics and link to geocoded addresses.
- Perform analysis with Lnight
- Complete internal manuscript and analysis review

Noise and Hypertension – NHS & NHS II

1 Exclusion Criteria at Baseline

- Self-report of physician diagnosis of hypertension
- Missing noise measure

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)



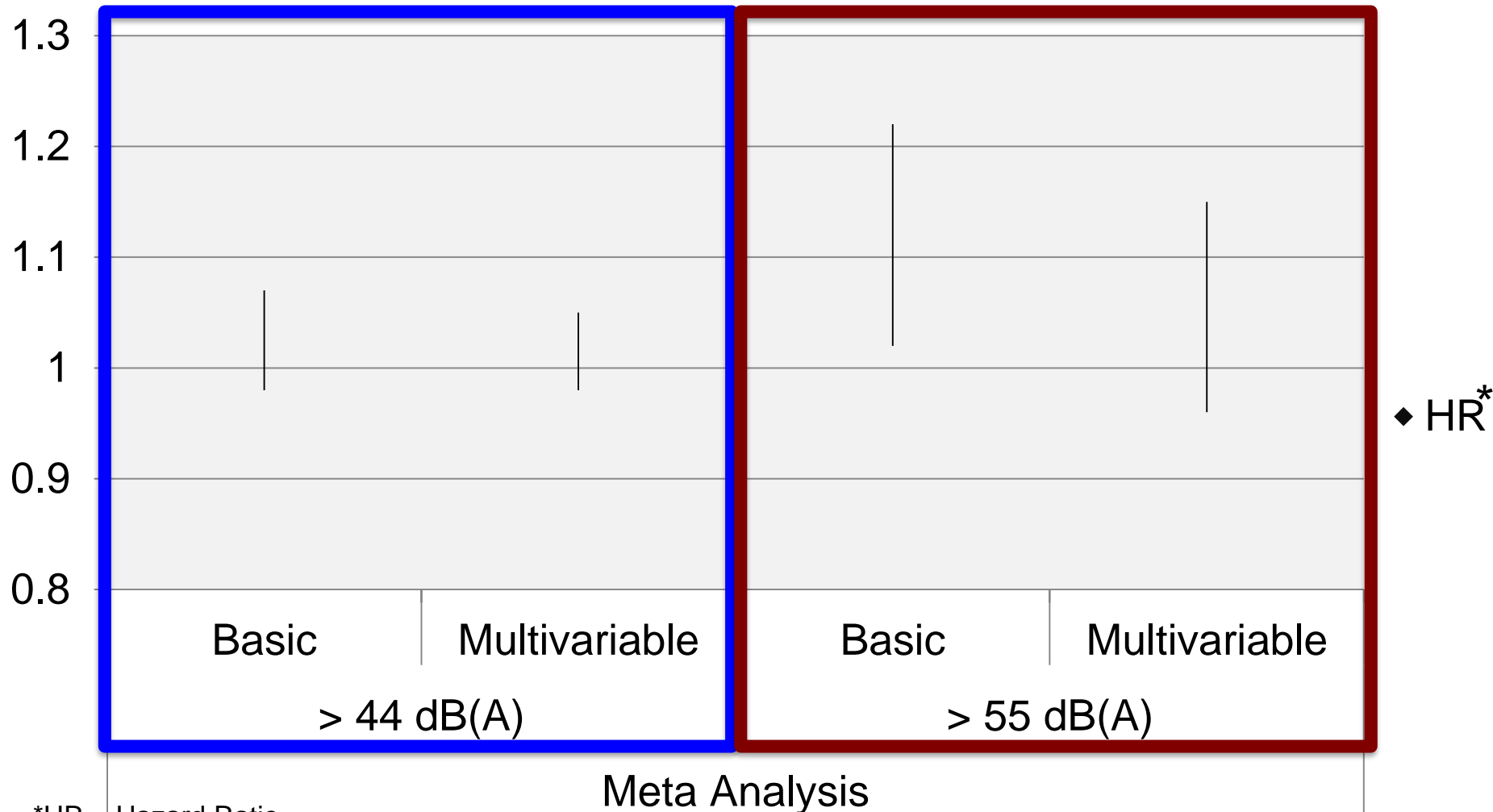
Participant - Characteristics

Characteristic	DNL ≤ 55 dB(A)	DNL > 55 dB(A)
	Mean (SD) or %	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/m ³)	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 Combined



*HR = Hazard Ratio

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

Noise and CVD– NHS (Original)

1 Exclusion Criteria at Baseline

- Heart attack (MI)
- Stroke
- Angina
- Coronary artery bypass graft surgery

2 Number at Risk at Baseline

NHS (1994): 106,264

3 Noise Exposure Distribution in NHS for Follow-Up

Total	DNL > 44 dB(A)	DNL > 55 dB(A)	DNL > 65 dB(A)
106,264	7,080 (6.7%)	848 (0.80%)	32 (0.03%)

Noise and CVD - NHS (Original)

1

Case Definition

Physician adjudicated incidence of:

- MI
- Stroke

during follow-up period of 1994-2010

2

Distribution of Cases by Noise Exposure in NHS

	Total Cases	Cases at DNL > 44 dB(A)	Cases at DNL > 55 dB(A)
CVD (Total)	7818	571 (7.3%)	56 (0.7%)
MI	3955	294 (7.4%)	29 (0.7%)
Stroke	3907	280 (7.2%)	27 (0.7%)

Objective:
Assess *health*
impacts of noise
- *sleep*

Sleep Questions

- Sleep duration: evaluated by "Average hours of sleep over a 24-hour period";
- Sleep quality: evaluated by multiple questions, including insomnia symptoms example "How often do you have trouble with waking up during the night?".

Timing

- Sleep duration: NHS (2000, 2002, 2008); NHSII (2001, 2009); and HPFS (2000, 2008)
- Sleep quality (insomnia symptoms): NHS (2000); NHSII (2001); and HPFS (2004)

Economic Impacts - *Motivation*

Existing work

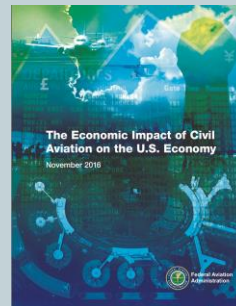
Noise impacts

- **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

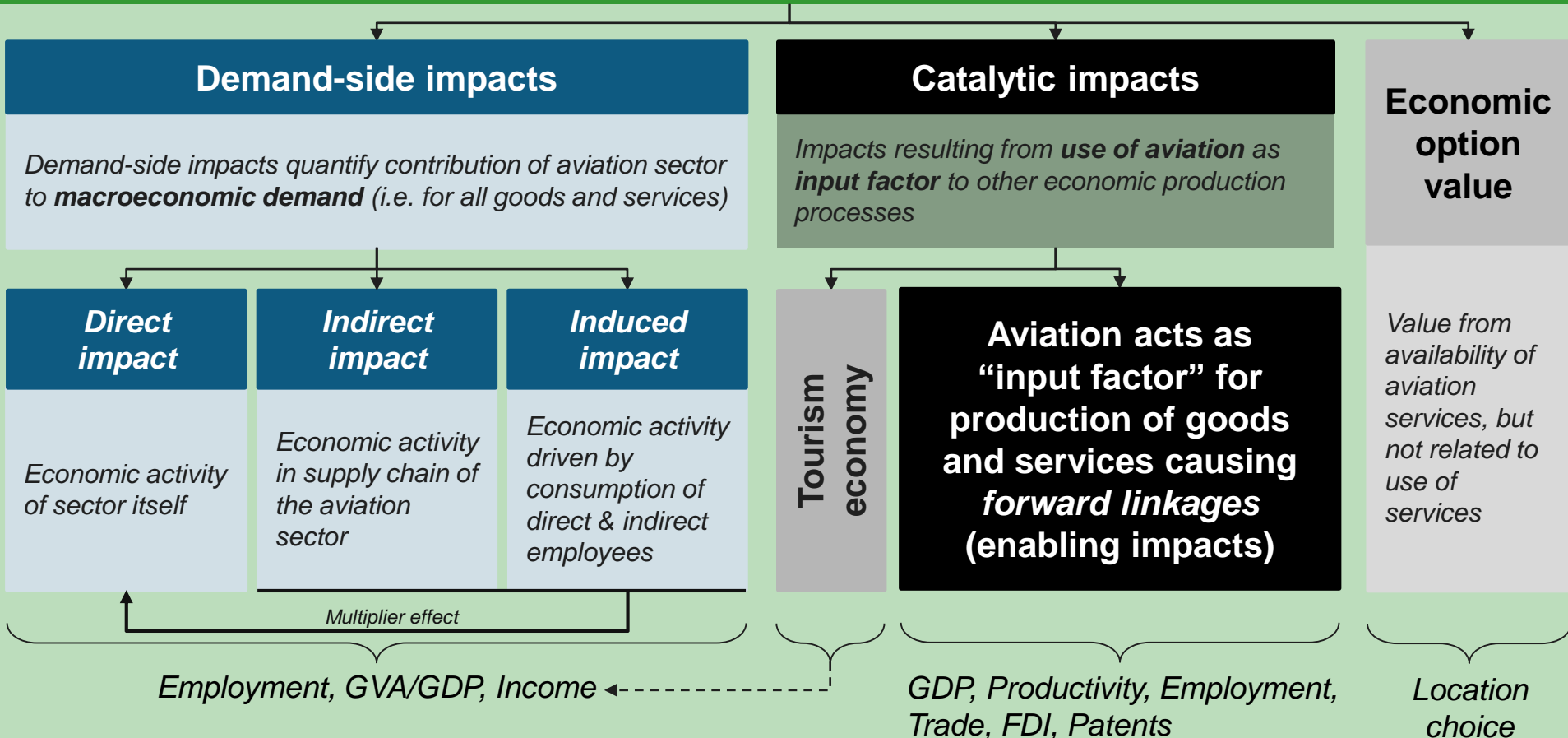
Economic Impacts – Framework

Noise impacts on businesses

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

VS.

Economic impacts of aviation



Economic Impacts – Project Outline

Summer /
Fall 2019

1

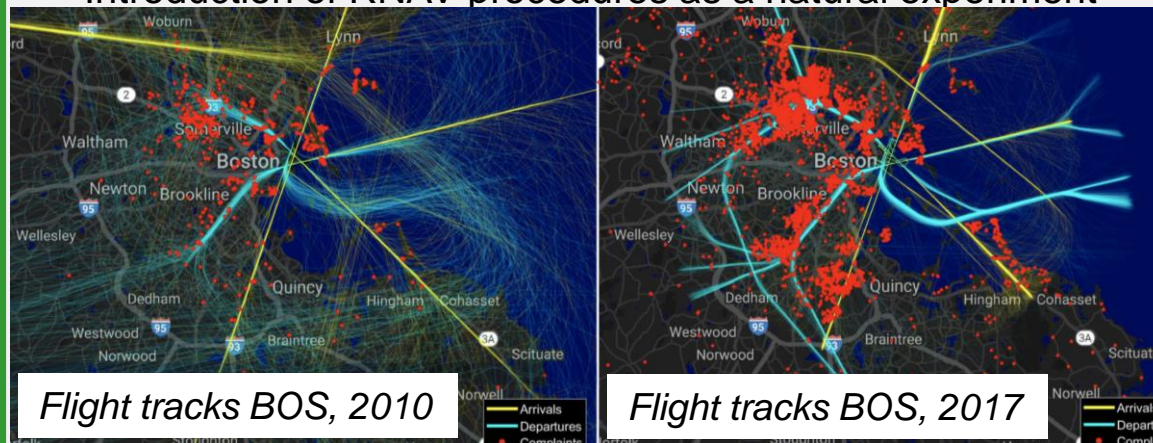
Literature review

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



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}

4

Run analysis

Spring
2022

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 (*past*-post doc), Chloe Kim (*past*-student), Daniel Nguyen (student)
- Harvard: Francine Laden, Jaime Hart, Susan Redline, Xiaoyu Li (post doc)
- MIT: R. John Hansman, Florian Allroggen, Carson Bullock (student)

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- 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.

- 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)