Cardiovascular Disease and Aircraft Noise Exposure

Project 03

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ASCENT
AVIATION SUSTAINABILITY CENTER

ASCENT Project 003

Cardiovascular Disease and Aircraft Noise Exposure

Boston University School of Public Health

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PM: Adam Scholten

Cost Share Partner: Donators to Nurses' Health Studies and Women's Health Initiative

Objective:

To evaluate relationships between aircraft noise exposure and health in existing health cohorts (Health Impacts)

Project Benefits:

1. Address gap of limited health and noise studies in the US, important for informing policy options.
2. Contribute to the body of knowledge of potential health impacts of aircraft noise.

Research Approach:

Exposure

Noise contours for 90 airports for 1995-2015 in 5-year intervals; metrics ***day-night average sound level (DNL)*** and ***nighttime sound level (Lnight / NL)***

Cohorts

- Nurses' Health Study (NHS) I and NHS II
- Women's Health Initiative (WHI)
- Hispanic Community Health Study/Study of Latinos (HCHS/SOL)
- National Longitudinal Study of Adolescent to Adult Health (Add Health)

Study Areas

Noise and hypertension, cardiovascular disease (CVD) intermediates & endpoints, sleep, & mental health

Major Accomplishments:

1. Papers accepted for publication (*most recent*)
   a. Noise Exposure Trends: *JESEE 2023*
   b. Noise and CVD: *Env Epi 2023*
   c. Noise and Sleep: *EHP 2023*
   d. Noise and Hypertension (WHI): *Environ Res 2023*
   e. Noise and Hypertension (NHS): *Environ Res 2022*
   f. Noise and Sociodemographics: *EHP 2022*

Future Work / Schedule:

1. Complete manuscript on noise and adiposity (NHS)
2. Complete manuscript on nighttime noise and hypertension (NHS)
3. Perform analysis of noise and diabetes (NHS)
4. Link noise estimates to HCHS/SOL & Add Health cohorts
5. Conduct literature review on noise and mental health
6. Explore potential mental health outcomes in cohorts

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ASCENT 03 – Past/Current/Future Work

Past/Current work

Noise and CVD in NHS

Use **Nurses' Health Studies** to study

- Cardiovascular Disease
- Hypertension
- Sleep

+ New Cohorts

- Women's Health Initiative (WHI)
- Hispanic Community Health Study / Study of Latinos (HCHS/SOL)
- The National Longitudinal Study of Adolescent to Adult Health (Add Health)

+ New Outcomes

- Intermediaries (e.g., adiposity and diabetes)
- Mental Health

Objective: Evaluate relationships between aircraft noise exposure and human health in diverse populations

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ASCENT 03 – Past/Current Work

- **Sociodemographic Patterns of Aircraft Noise**
  - Simon et al. 2022 *EHP*
- **Trends in Aircraft Noise Exposure**
  - Nguyen et al. 2023 *JESEE*
- **Noise and Hypertension**
  - DNL in NHS (Kim et al. 2022 *Environ Res*)
  - DNL and Lnight/NL in WHI (Nguyen et al. 2023 *Environ Res*)
  - Lnight/NL in NHS (Peters et al. in progress)
- **Noise and CVD, CVD Mortality, & All-Cause Mortality**
  - Grady et al. 2023 *Env Epi*
- **Noise and Sleep Duration/Quality**
  - Bozigar et al. 2023 *EHP*

Trends in Aircraft Noise Exposure

Published in peer-reviewed journal *Journal of Exposure Science and Environmental Epidemiology (JESEE)*

Highlights:

- **Estimated changes in noise exposure areas** at DNL 45, 65, and NL 45 using linear fixed effects models
- **Identified distinct groups of airports sharing underlying characteristics** using group-based trajectory modeling.
- Overlaid noise contours and Census tract data for 2000-2015, **estimated total and sub-population (race/ethnicity) exposure changes** and **found,** compared to non-Hispanic White population, **other racial/ethnic groups experienced higher proportions of exposure relative to their subgroup populations** across all years**.**

Hypertension (NHS) – DNL…

Published in peer-reviewed journal *Environmental Research (Environ Res)*

Highlights:

- **Found suggestive associations between increased levels of DNL and incident hypertension**
- Relationships were not affected by additional adjustment for particulate matter air pollution

…to Nighttime Noise (NL)

In progress:

- Analysis of nighttime noise (Lnight/NL) & incident hypertension
- Includes measures of air pollution (NO_2 and $PM_{2.5}$)
- Includes updated measure of neighborhood socioeconomic status
  - Incorporating 9 area (Census) measures

Hypertension (NHS) – Lnight/NL

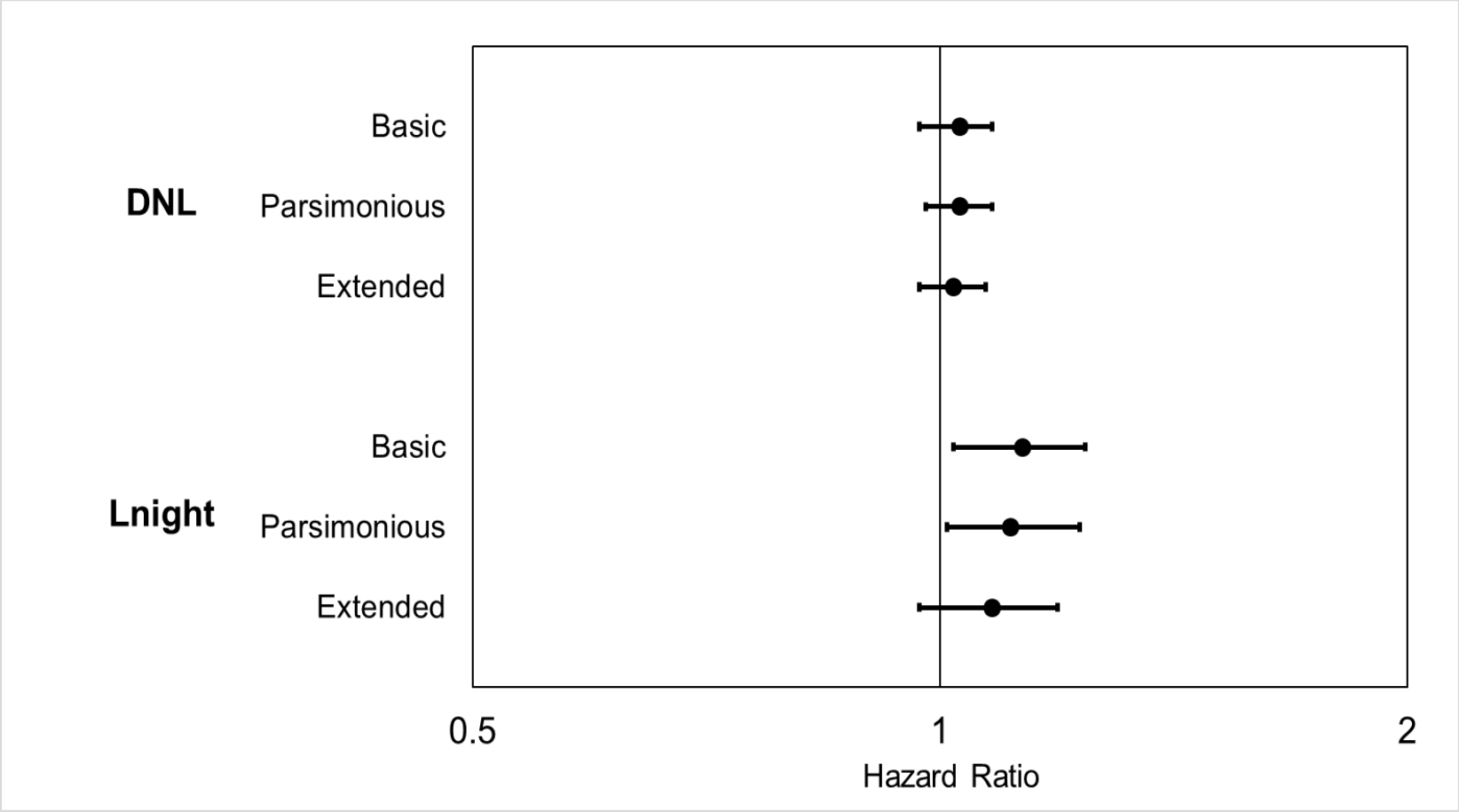
PRELIMINARY RESULTS

NL Distribution among Participants at Risk for Hypertension				
NL, dB	**NHS I (n=63,229)**		**NHS II (n=98,938)**	
	At risk	Cases	At risk	Cases
<45	62,806	32,996	98,036	28,042
45 – 49	343	150	704	163
50 – 54	67	36	164	43
55-59	13	7	32	7
60-64	0	1	2	1
≥65	0	0	0	0

Hypertension (NHS) – DNL & Lnight/NL

Dichotomized at 45 dB

PRELIMINARY RESULTS



Basic model adjustment: age and calendar year.
Parsimonious model: adjustment Basic + race, physical activity, smoking status, alcohol use, DASH, spouse's education attainment, nSES, region of residence, NO_2, and $PM_{2.5}$.
Extended model adjustment: Parsimonious + BMI, menopausal status, medications, and family history of hypertension.

ASCENT 03 – Past/Current/Future Work

Past/Current work

Noise and CVD in NHS

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+ New Cohorts

- Women's Health Initiative (WHI)
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+ New Outcomes

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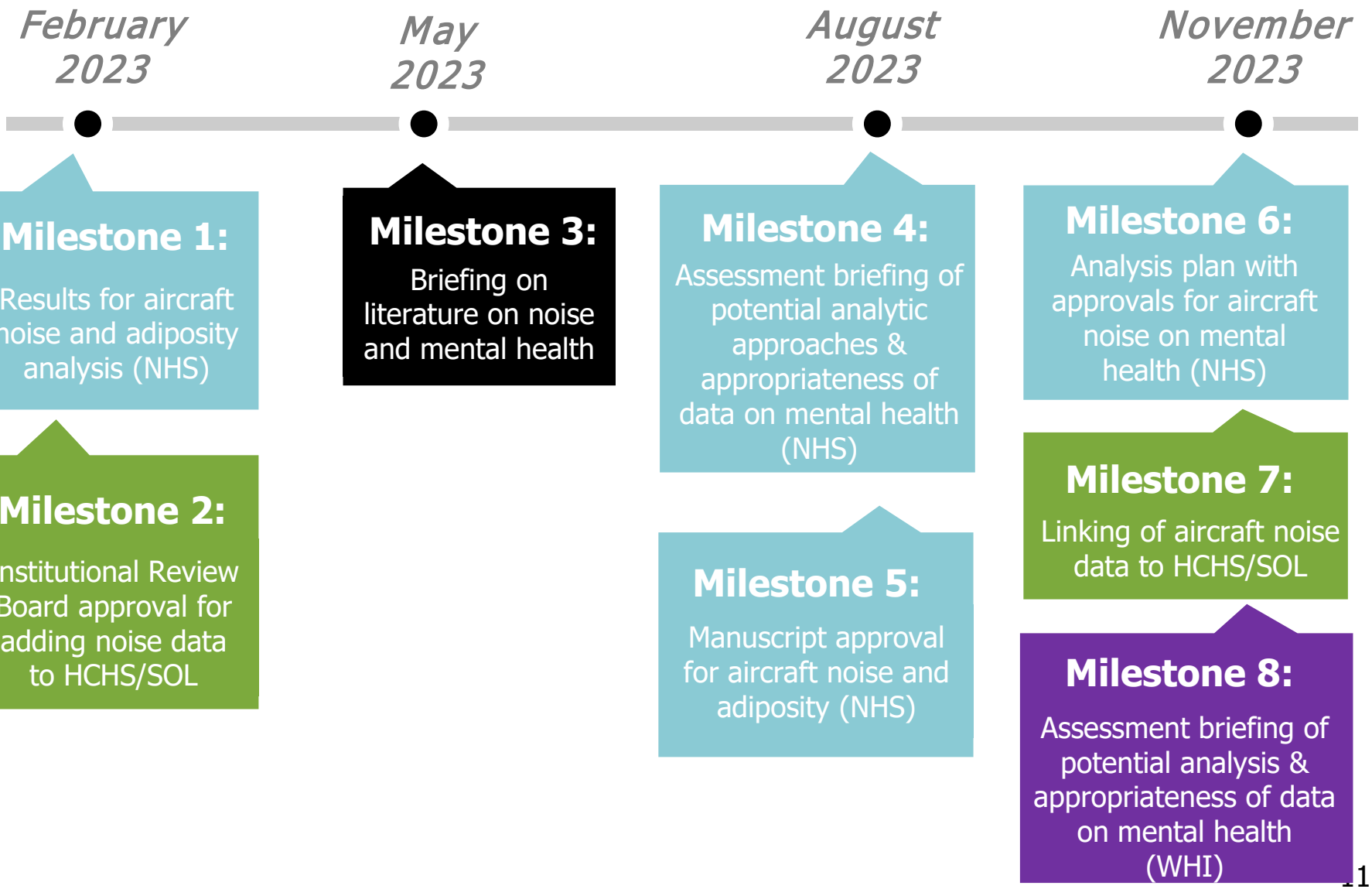
- Mental Health

Objective: Evaluate relationships between aircraft noise exposure and human health in diverse populations

Health Impacts – Project Outline



Continued Work: Nurses Health Studies (NHS)

Background:

- Study Population:
  - >121,700 pre- & post-menopausal female nurses across the US
  - Participant-level data & geocoded addresses over time
- Study Period:
  - Recruited in 1976 (NHS I) and 1989 (NHS II) and followed every 2 years
- Research Plans:
  - Examine noise with **mental health outcomes**
  - Examine noise with **CVD intermediates (e.g., adiposity, diabetes)**

Progress:

- Examining noise and adiposity (manuscript in progress)
- Examining noise and diabetes (analysis in progress)

Nurses' Health Study

New Outcome: DNL and Adiposity (Preliminary Results)

Nurses' Health Study

Study Population: NHS I and NHS II participants from 1994-2014

Exposure: Annualized daily averages (DNL)

Outcome: Body mass index (body weight/height-squared) – repeated measures

Model	OR (95% CI)				p for trend
	<45 dB	45-54 dB	55-64 dB	≥65 dB	
Basic	*Ref*	1.10 (1.07, 1.14)	1.23 (1.13, 1.33)	1.41 (0.97, 2.06)	<0.01
Parsimonious	*Ref*	1.05 (1.01, 1.08)	1.14 (1.05, 1.23)	1.26 (0.87, 1.83)	<0.01
Fully Adjusted	*Ref*	1.04 (1.00, 1.07)	1.10 (1.02, 1.20)	1.25 (0.86, 1.81)	<0.01

* OR – Odds Ratio; CI – Confidence Interval

Models adjusted for 1) age, age^2, survey period, cohort; 2) add other demographics, behaviors, comorbidities; 3) add ambient environmental factors - particulate matter of size equal to or smaller than 2.5 microns ($PM_{2.5}$), greenness (Normalized Difference Vegetation Index, NDVI), light at night (LAN), neighborhood socioeconomic status, environmental noise.

PRELIMINARY RESULTS

New Outcome: DNL and Diabetes

Nurses' Health Study

Study Population: NHS I and NHS II participants from 1994-2016

Exposure: Annualized daily averages (DNL)

Outcome: Type 2 diabetes mellitus (T2DM)

- Reporting T2DM diagnosis on questionnaire
- Sent follow-up questionnaire to ascertain diagnosis date and additional info:
- Met ≥1 of the 1998 American Diabetes Association criteria:
  - ≥ 2 elevated plasma glucose concentrations (in absence of symptoms)
  - 1 elevated plasma glucose concentration and ≥1 T2DM symptoms
  - Treatment with hypoglycemic medication

Methods: Similar methods to previous noise and incident health outcomes (Cox proportional hazards models)

Adjust for: air pollution (particulate matter, nitrogen dioxide), region, race/ethnicity, individual-level and neighborhood-level SES, physical activity, diet, alcohol intake, smoking, family history of T2D

New Outcome: DNL and Diabetes (Preliminary)

Nurses' Health Study

NL, dB	NHS I		NHS II	
	At risk	Cases	At risk	Cases
<45	90,946	7,076	100968	6,391
45 – 49	4,340	313	5281	276
50 – 54	2,018	165	2,419	137
55-59	751	60	954	56
60-64	179	17	238	20
≥65	39	3	55	7
Total	98,273	7,634	109,915	6,887

PRELIMINARY RESULTS

Continued Work: Women's Health Initiative (WHI)

Background

- Study Population:
  - >161,000 post-menopausal women recruited from centers across the US
  - Participant-level data & geocoded addresses over time
- Study Period:
  - Recruited 1993 – 1998
  - Prospective study up to 2012
- Research Plans:
  - Examine noise with **mental health outcomes** and **CVD intermediaries and endpoint**

New Cohort: Hispanic Community Health Study / Study of Latinos (HCHS/SOL)

Background:

- Study Population:
  - >16,000 Hispanic/Latino participants aged 18-64 across the US (Chicago, Miami, San Diego, & Bronx area of New York City)
  - Participant-level data & geocoded addresses over time
- Study Period:
  - Recruited 2008-2011 & seen every 6 years
  - Second visit 2014-2017 & third visit 2020-2023
- Research Plans:
  - Examine noise with **previously studied outcomes** in NHS & WHI (**CVD, hypertension, sleep**)
  - Examine noise with **mental health & CVD intermediates**

Progress:

- Developed plan for noise data use – incorporating DUA into study.
- Received Institutional Review Board approval

New Cohort: The National Longitudinal Study of Adolescent to Adult Health (Add Health)

Background:

- Study Population:
  - Nationally representative sample of >20,000 adolescents over 14 years old followed over 20 years
  - Participant-level data & geocoded addresses over time
- Study Period:
  - Recruited 1994-1995
  - Followed for five waves, up to 2016-2018
- Research Plans:
  - Examine DNL & NL with **previously studied outcomes** in NHS & WHI (e.g., **hypertension, sleep**)
  - Examine DNL & Lnight/NL with **mental health & CVD intermediates**

Progress:

- Received ancillary study approval
- Received Institutional Review Board approval

Summary

- **Previous findings have shown mixed results, with limitations in:**
  - Cohort demographics
  - Aircraft noise exposure timing
  - Aircraft noise exposure availability (few above ≥45 dB)

- **New cohorts and outcomes have the potential to provide insight on:**
  - Health effects among various demographic groups
  - Critical time windows of exposure (e.g., earlier life exposure)
  - Understudied yet biologically-plausible outcomes

Publications (recent)

- Grady ST, Hart JE, Laden F, Roscoe C, Nguyen DD, Nelson EJ, Bozigar M, VoPham T, Manson JE, Weuve J, Adar SD, Forman JP, Rexrode K, Levy JI, Peters JL. Associations between long-term aircraft noise exposure, cardiovascular disease, and mortality in US cohorts of female nurses. Environmental Epidemiology 2023, 7(4): e259. doi: 10.1097/EE9.0000000000000259.
- Bozigar M, Huang T, Redline S, Hart JE, Grady ST, Nguyen DD, James P, Nicholas B, Levy JI, Laden F, Peters JL. Associations between Aircraft Noise Exposure and Self-Reported Sleep Duration and Quality in the United States-Based Prospective Nurses' Health Study Cohort. Environmental Health Perspectives 2023; 131(4):47010. doi: 10.1289/EHP10959.
- Nguyen DD, Whitsel EA, Wellenius GA, Levy JI, Leibler JH, Grady ST, Stewart JD, Fox MP, Collins JM, Eliot MN, Malwitz A, Manson JE, Peters JL. Long-term aircraft noise exposure and risk of hypertension in postmenopausal women. Environ Res. 2022 Dec 9;218:115037. doi: 10.1016/j.envres.2022.115037.
- Simon MC, Hart JE, Levy JI, VoPham T, Malwitz A, Nguyen DD, Bozigar M, Cupples LA, James P, Laden F, Peters JL. Sociodemographic Patterns of Exposure to Civil Aircraft Noise in the United States 2022; 130(2) https://doi.org/10.1289/EHP9307.
- Kim CS, Grady ST, Hart JE, Laden F, VoPham T, Nguyen DD, Manson JE, James P, Forman JP, Rexrode KM, Levy JI, Peters JL. Long-term aircraft noise exposure and risk of hypertension in the Nurses' Health Studies. Environmental Research, 2021; 207:112195. doi: 10.1016/j.envres.2021.112195.

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