ASCENT Project 003

Cardiovascular Disease and Aircraft Noise Exposure

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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.
3. Responsive to Section 189 of the 2018 FAA Reauthorization.

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
   a. Noise and Sleep: *EHP 2023*
   b. Noise and Hypertension (WHI): *Environ Res 2023*
   c. Noise and Hypertension (NHS): *Environ Res 2022*
   d. Noise and Sociodemographics: *EHP 2022*
   e. Aircraft Noise Review: *Curr Epidemiol Rep 2018*

2. Paper submitted for publication
   a. Noise and CVD: *Environ Epi*
   b. Noise Trends: *JESEE*

Future Work / Schedule:

1. Continue manuscript preparation for noise and adiposity (NHS)
2. Seek analysis plan approval for noise and diabetes (NHS)
3. Link noise estimates to HCHS/SOL & Add Health cohorts
4. Conduct literature review on noise and mental health
5. Explore potential mental health outcomes in cohorts

This research was funded by the U.S. Federal Aviation Administration Office of Environment and Energy through ASCENT, the FAA Center of Excellence for Alternative Jet Fuels and the Environment, project 003 through FAA Award Number 13-C-AJFE-BU under the supervision of Adam Scholten. Any opinions, findings, conclusions or recommendations expressed in this this material are those of the authors and do not necessarily reflect the views of the FAA.

ASCENT 03 – Past/Current/Future Work

Existing work

Noise and CVD in NHS

Use **Nurses' Health Studies** to study

- Cardiovascular Disease
- Hypertension
- Sleep

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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)

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New Outcomes

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

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

ASCENT 03 – Past/Current/Future Work

Existing work

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New Cohorts

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New Outcomes

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

ASCENT 03 – Past/Current Work

- **Sociodemographic Patterns of Aircraft Noise Exposure**
  - Simon et al. 2022 *EHP*
- **Trends in Aircraft Noise Exposure**
  - Nguyen et al. submitted to *JESEE*
- **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)
- **Sleep Duration/Quality**
  - Bozigar et al. in press *EHP*
- **CVD, CVD Mortality, & All-Cause Mortality**
  - Grady et al. revise and resubmit

Sociodemographic Patterns of Aircraft Noise Exposure

Published in peer-reviewed journal *Environmental Health Perspectives (EHP)*

Highlights:

- Compared exposure of U.S. Census block groups by race/ ethnicity, education, and income across three noise groups/ thresholds (DNL 45 dB, 55 dB, 65 dB)
- Overall, block groups with **higher Hispanic population and proportion of residents with ≤ high school education had higher odds of noise exposure**
- There was substantial heterogeneity across airports

Trends in Aircraft Noise Exposure

Currently under review at the *Journal of Exposure Science and Environmental Epidemiology (JESEE)*

Methods:

- **Estimated changes in noise exposure areas** at DNL 45, 65, and NL 45 using linear fixed effects models
- Group-based trajectory modeling to **identify distinct groups of airports sharing underlying characteristics**
- Overlaid noise contours and Census tract data from US Census Bureau and American Community Surveys for 2000-2015 to **estimate total and sub-population (race/ethnicity) exposure changes**

Hypertension (NHS) – DNL

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

Highlights:

- **Found suggestive associations between increased levels of DNL and incident hypertension**
- In fully-adjusted models, participants exposed to ≥45 & ≥55 dB had 3% (95% CI: -1%, 7%) and 6% (95% CI: -2%, 15%) increased risks compared to the unexposed
- Relationships were not affected by additional adjustment for particulate matter air pollution

In progress:

- Analysis of nighttime noise (Lnight/NL) & incident hypertension

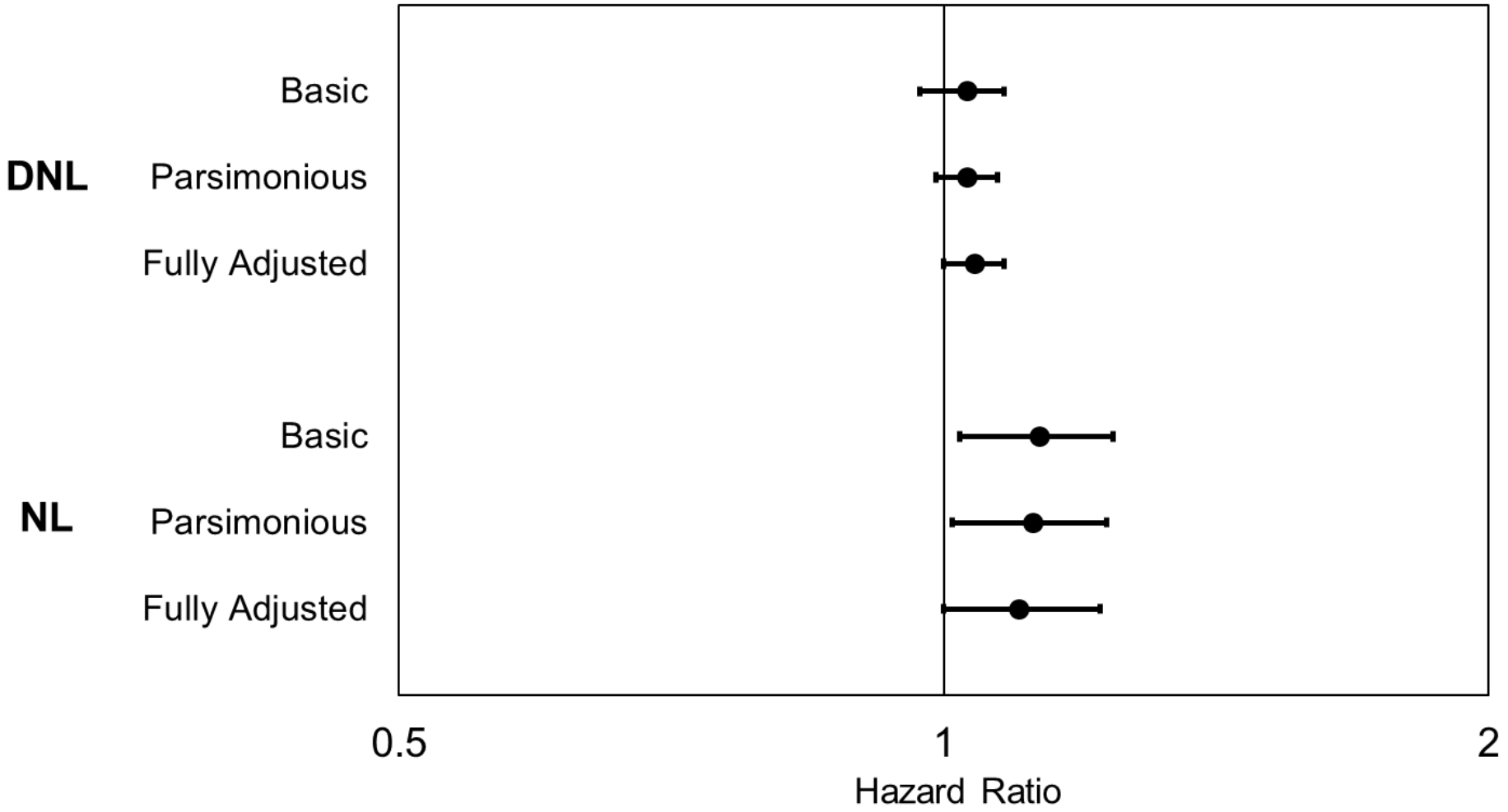
Hypertension (NHS) – Lnight/NL

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

Hypertension in WHI – DNL & Lnight/NL

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

Highlights:

- About 7,570 participants with DNL and 933 with Lnight/NL exposure ≥45 dB at risk of hypertension
- Conducted time-varying Cox proportional hazards regression models similar to NHS analyses

DNL ≥45 vs <45 dB	NL ≥45 vs <45 dB
HR (95% CI)	**HR (95% CI)**
1.00 (0.93, 1.08)	1.06 (0.91, 1.24)

- Found elevated risk among certain subgroups, such as those living in areas with lower population density or nitrogen dioxide

Sleep

Published in peer-reviewed journal *Environmental Health Perspectives (EHP)*

Highlights:

- Investigated associations between Lnight/NL and insufficient sleep and poor sleep quality in NHS I
- In multivariable-adjusted longitudinal models those exposed to higher levels of Lnight/NL and DNL had higher odds of insufficient sleep compared with those not exposed to Lnight/NL and DNL
- Relationship pronounced in participants living in the west, near cargo airports, and near water-adjacent airports
- No relationship between noise and sleep quality.

Cardiovascular Disease (CVD), CVD Mortality, All-Cause Mortality

Submitted to peer-reviewed journal *Environmental Epidemiology (Environ Epi)* – responding to reviewer comments

Highlights:

- Investigated associations between DNL and risk of cardiovascular disease (CVD), CVD mortality, & all-cause mortality in NHS (NHS I & NHS II)
- Categorized DNL at multiple cut-points – small numbers at higher exposures
- **Did not find associations between DNL & CVD incidence or all-cause mortality**
- Found suggestive associations between DNL & CVD mortality, yet not precise as sample size was small

PRELIMINARY RESULTS

CVD, CVD Mortality, All-Cause Mortality

Study Population
- NHS I and NHS II participants
- Study periods 1994-2014 (NHS I) and 1995-2013 (NHS II)

Exposure
- Annualized daily averages (DNL)

Outcome
- Cardiovascular disease incidence (heart attack and stroke)
- Cardiovascular disease mortality
- All-cause mortality

Analysis
- Time-varying Cox proportional hazards regression models

PRELIMINARY RESULTS

CVD (NHS) - Distribution

DNL Distribution among Participants at Risk for CVD				
DNL, dB	NHS I (n=57,306)		NHS II (n=60,058)	
	At risk	Cases	At risk	Cases
<45	47,976	3,275	49,523	502
45 – 49	5,507	367	6,152	68
50 – 54	2,565	182	2,884	28
55-59	965	75	1,139	10
60-64	241	14	290	6
≥65	52	2	70	0

PRELIMINARY RESULTS

CVD Incidence (NHS) - Results

PRELIMINARY RESULTS

DNL, dB	Cases	HR (95% CI)		
		Basic	Parsimonious	Fully Adjusted
≥45	752	1.00 (0.93, 1.09)	1.00 (0.92, 1.08)	0.98 (0.91, 1.07)
<45	3,777	*Ref*	*Ref*	*Ref*
≥50	317	1.01 (0.90, 1.13)	1.00 (0.89, 1.12)	0.97 (0.86, 1.09)
<50	4,212	*Ref*	*Ref*	*Ref*

* HR – Hazards Ratio; CI – Confidence Interval
Meta-analysis of NHS I and NHS II cohorts.
Models adjusted for 1) age, time period; 2) add other demographics, ambient environmental factors; 3) add other comorbidities, behavioral and health factors

CVD Mortality (NHS I) - Results

PRELIMINARY RESULTS

DNL, dB	Cases	HR (95% CI)		
		Basic	Parsimonious	Fully Adjusted
≥45	536	1.08 (0.98, 1.19)	1.03 (0.93, 1.13)	1.01 (0.92, 1.12)
<45	2,602	*Ref*	*Ref*	*Ref*
≥50	239	1.15 (1.01, 1.32)	1.07 (0.94, 1.23)	1.03 (0.90, 1.19)
<50	2,899	*Ref*	*Ref*	*Ref*

* HR – Hazards Ratio; CI – Confidence Interval
Models adjusted for 1) age, time period; 2) add other demographics, ambient environmental factors; 3) add other comorbidities, behavioral and health factors

ASCENT 03 – Past/Current/Future Work

Existing work

Noise and CVD in NHS

Use **Nurses' Health Studies** to study

- Cardiovascular Disease
- Hypertension
- Sleep

+ New Cohorts

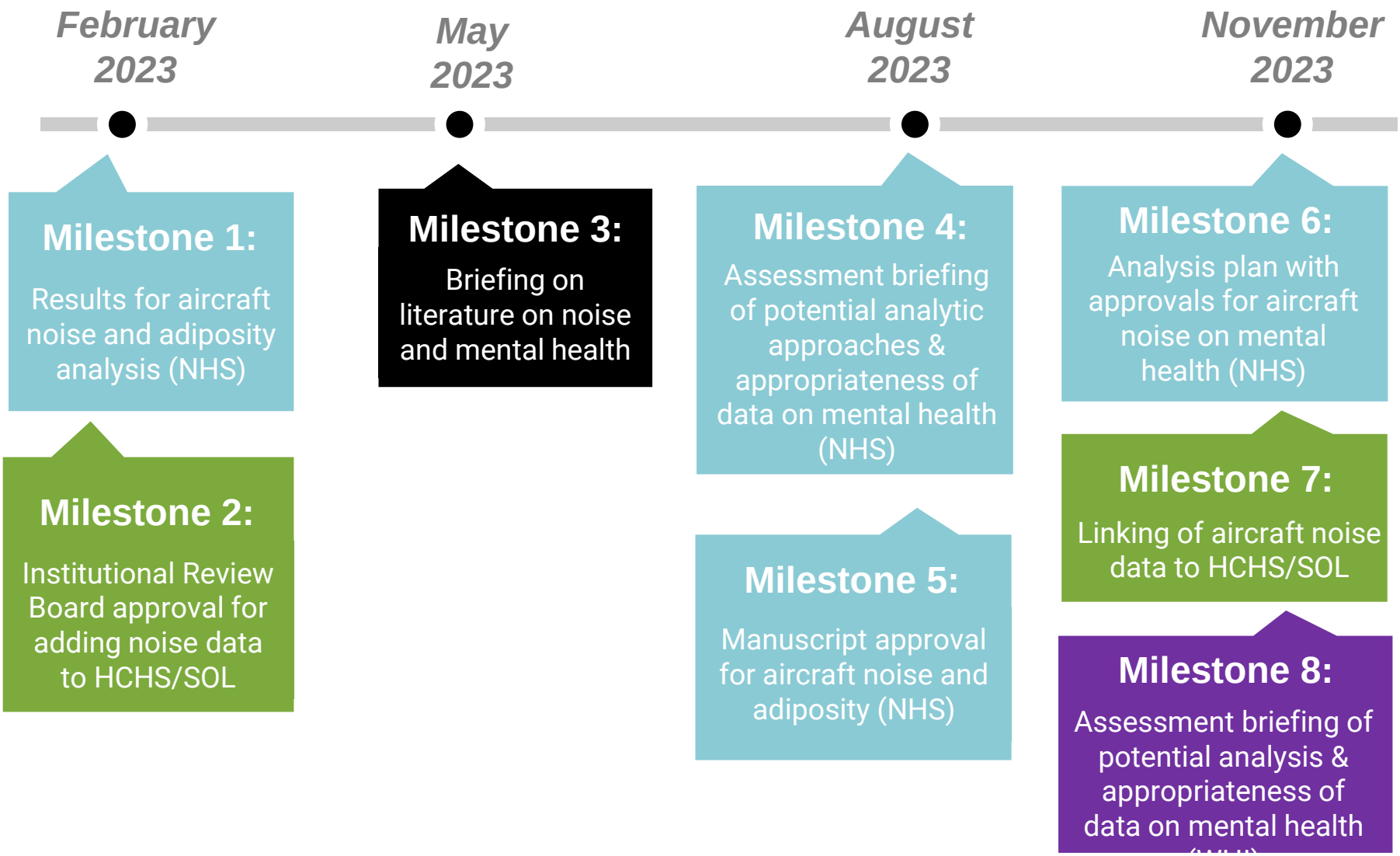
- Women's Health Initiative (WHI)
- Hispanic Community Health Study / Study of Latinos (HCHS/SOL)
- The National Longitudinal Study of Adolescent to Adult Health (Add Health)

+ New Outcomes

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

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

Health Impacts – Project Outline



Current/Future Work: Nurses Health Studies (NHS)

- 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

- Plans in Progress:
  - Examine noise with **mental health outcomes**
  - Examine noise with **CVD intermediates (e.g., adiposity, diabetes)**

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)

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

Future Work: Women's Health Initiative (WHI)

- 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**

Future Work: Hispanic Community Health Study / Study of Latinos (HCHS/SOL)

- 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**

Future Work: The National Longitudinal Study of Adolescent to Adult Health (Add Health)

- 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 (**hypertension, sleep**)
  - Examine DNL & Lnight/NL with **mental health & CVD intermediates**

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

- Bozigar M, Huang T, Redline S, Hart JE, Grady ST, Nguyen DD, James P, Levy JI, Laden F, Peters JL. Associations between aircraft noise exposure and self-reported sleep in the US-based prospective Nurses' Health Study cohort. EHP. In Press.
- 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.
- 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.

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