Preterm birth rates among mothers exposed to ultrafine particles from jet exhaust

Presented by:
Neelakshi Hudda, Ph.D.
Research Assistant Professor
Tufts University

Original work by: Wing, S. E.; Larson, T. V.; Hudda, N.; Boonyarattaphan, S.; Fruin, S.A., Ritz, B.

Tufts UNIVERSITY | SCHOOL OF ENGINEERING Civil and Environmental Engineering

Corresponding peer-reviewed publication:

Wing, S. E.; Larson, T. V.; Hudda, N.; Boonyarattaphan, S.; Fruin, S.A., Ritz, B. **Preterm Birth among Infants Exposed to in Utero Ultrafine Particles from Aircraft Emissions**. *Environ. Health Perspect.* 2020, *128* (4), 047002. https://ehp.niehs.nih.gov/doi/full/10.1289/EHP5732

Also see: **Move Over, Traffic: Aircraft Emissions and Preterm Birth**, Konkel et al., EHP Science Selection, 2020 https://doi.org/10.1289/EHP7161

Sam Wing
Clinical Research Administrator
City of Hope, Los Angeles, CA

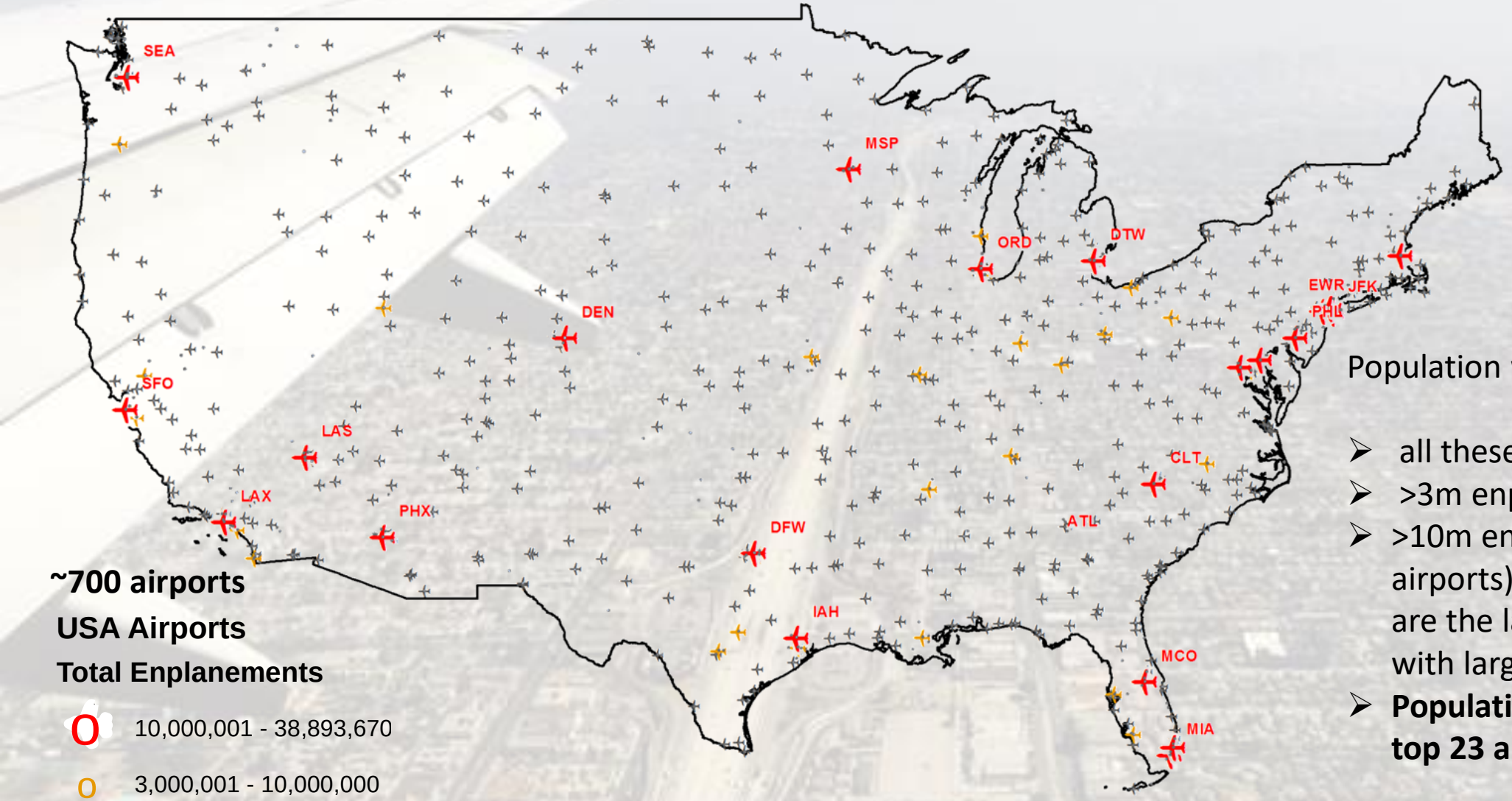
Sarunporn Boonyarattaphan
Dept. of Civil and Environmental Engg.
Univ. of Washington, Seattle, WA

Timothy V. Larson
Professor, Dept. of Civil and Environmental Engg.
Univ. of Washington, Seattle, WA

Scott A Fruin
Assistant Professor, Dept. Of Preventive Medicine
Univ. of Southern California Los Angeles, CA

Beate Ritz
Professor, Dept. Of Epidemiology
Univ. of California Los Angeles, CA

Research has implications for large populations in near-airport communities that rank high on environmental justice metrics



~700 airports

USA Airports

Total Enplanements

- 10,000,001 - 38,893,670
- 3,000,001 - 10,000,000
- 257 - 3,000,000

Population within 3 miles of

- all these airports: 34 million
- >3m enplanements: 6.2 million
- >10m enplanements (23 airports): 3.2 million BUT these are the largest of the airports with large impact zones!
- **Population within 10 miles of top 23 airports: 33.3 million**

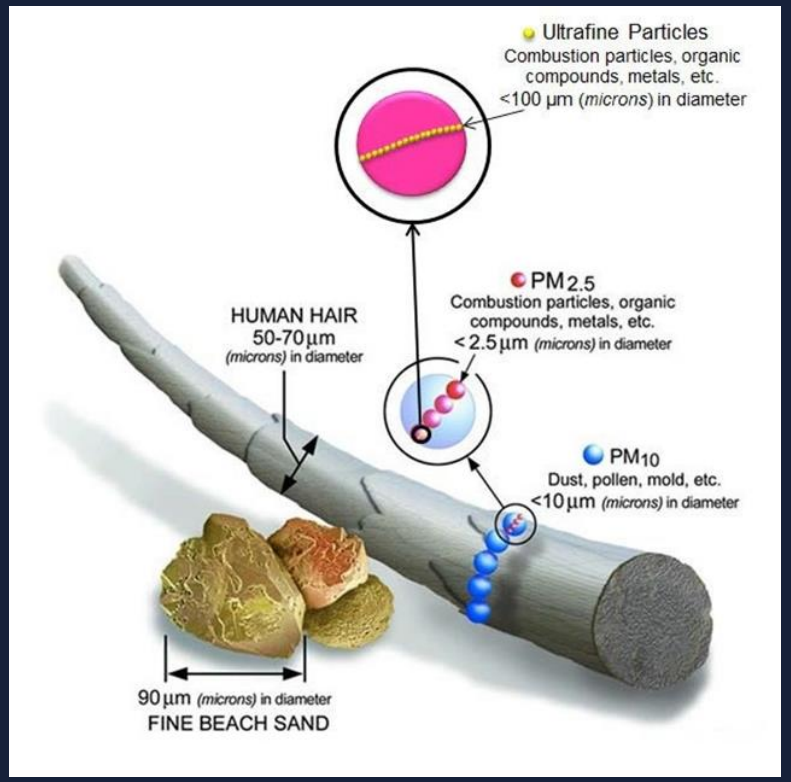
Background and Motivation

- Approximately 10% births in the United States are preterm increasing the infant's risk for developing complications.
- Exposure to ambient air pollution during pregnancy has been identified as a risk factor for adverse birth outcomes, including preterm birth (PTB).
- The effect of ambient air pollution - mostly originating from ground-transportation emissions - on birth outcomes has been extensively studied, but the effects of aircraft emissions have not.

Ultrafine Particles: our primary pollutant of interest

Ultrafine particles (UFP)

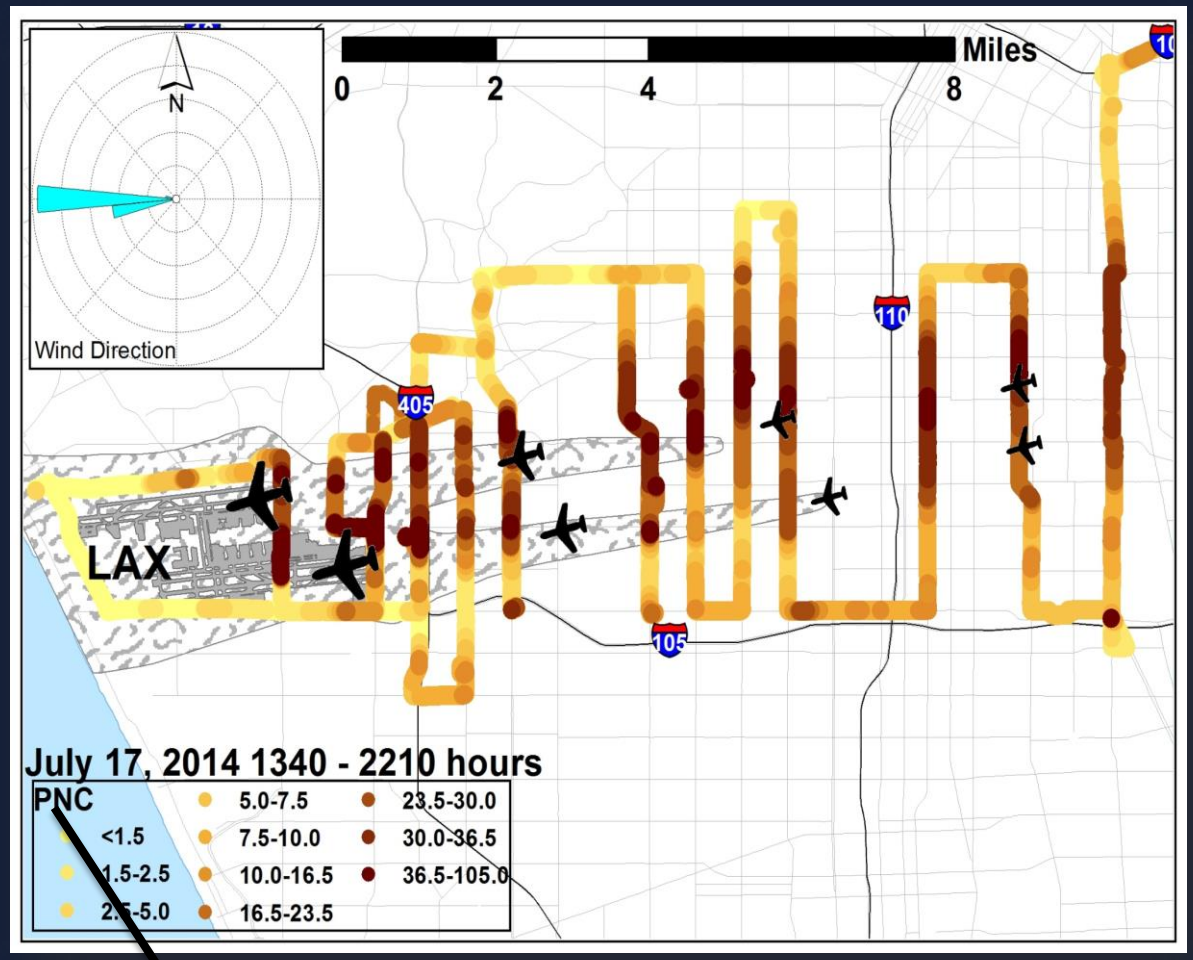
- ❑ defined as <100 nm/0.1 µm
- ❑ small, numerous, not massive
- ❑ reported as a count/cm^3 or Particle Number Concentration (PNC)
- ❑ markers of fresh emissions



Sizes of particulate matter compared to human hair and beach sand. Illustration: Eda Lu, based on US EPA "Particulate Matter (PM) Pollution" from the book "Particles in the Air" https://now.tufts.edu/articles/toxic-air-we-breathe

Study Setting: LAX/Los Angeles International

Aviation activity at Los Angeles International Airport (LAX) produces ground-level ultrafine particle concentrations more than twice the nearby ambient levels at distances up to 16 km away from the airport.



Particle number concentration in 1000s/cm^3

Study Setting: LAX/Los Angeles International

Aviation activity at Los Angeles International Airport (LAX) produces ground-level ultrafine particle concentrations more than twice the nearby ambient levels at distances up to 16 km away from the airport.

ENVIRONMENTAL Science & Technology

Article

pubs.acs.org/est

Terms of Use

Emissions from an International Airport Increase Particle Number Concentrations 4-fold at 10 km Downwind

Neelakshi Hudda,[†] Tim Gould,[‡] Kris Hartin,[§] Timothy V. Larson,[‡] and Scott A. Fruin*[,†,∥]

[†]Keck School of Medicine, Department of Preventive Medicine, University of Southern California, Los Angeles, California 90089, United States

[‡]Department of Civil and Environmental Engineering, University of Washington, Seattle, Washington 98195, United States

[§]Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, Washington 98195, United States

Supporting Information

ABSTRACT: We measured the spatial pattern of particle
concentrations downwind from the Los Angeles Internat
(LAX) with an instrumented vehicle that enabled us to cov
than allowed by traditional stationary measurements. La
adversely impacted air quality much farther than reporte
airport studies. We measured at least a 2-fold inc
concentrations over unimpacted baseline PN concentr
most hours of the day in an area of about 60 km^2 that exten
(10 miles) downwind and a 4- to 5-fold increase to 8–
miles) downwind. Locations of maximum PN concen
aligned to eastern, downwind jet trajectories during preva
winds and to 8 km downwind concentrations exceeded 75
cm^3, more than the average freeway PN concentration in
During infrequent northerly winds, the impact area remain
would cause an impact equivalent to that measured in this s
was estimated to be 280–790 km. The total freeway len
emissions are a major source of PN in Los Angeles that are
They also indicate that the air quality impact areas of maj

ENVIRONMENTAL Science & Technology

Article

pubs.acs.org/est

International Airport Impacts to Air Quality: Size and Related Properties of Large Increases in Ultrafine Particle Number Concentrations

N. Hudda and S. A. Fruin*[,†]

Keck School of Medicine, Environmental Health Division, University of Southern California, Los Angeles, California 90033, United States

Supporting Information

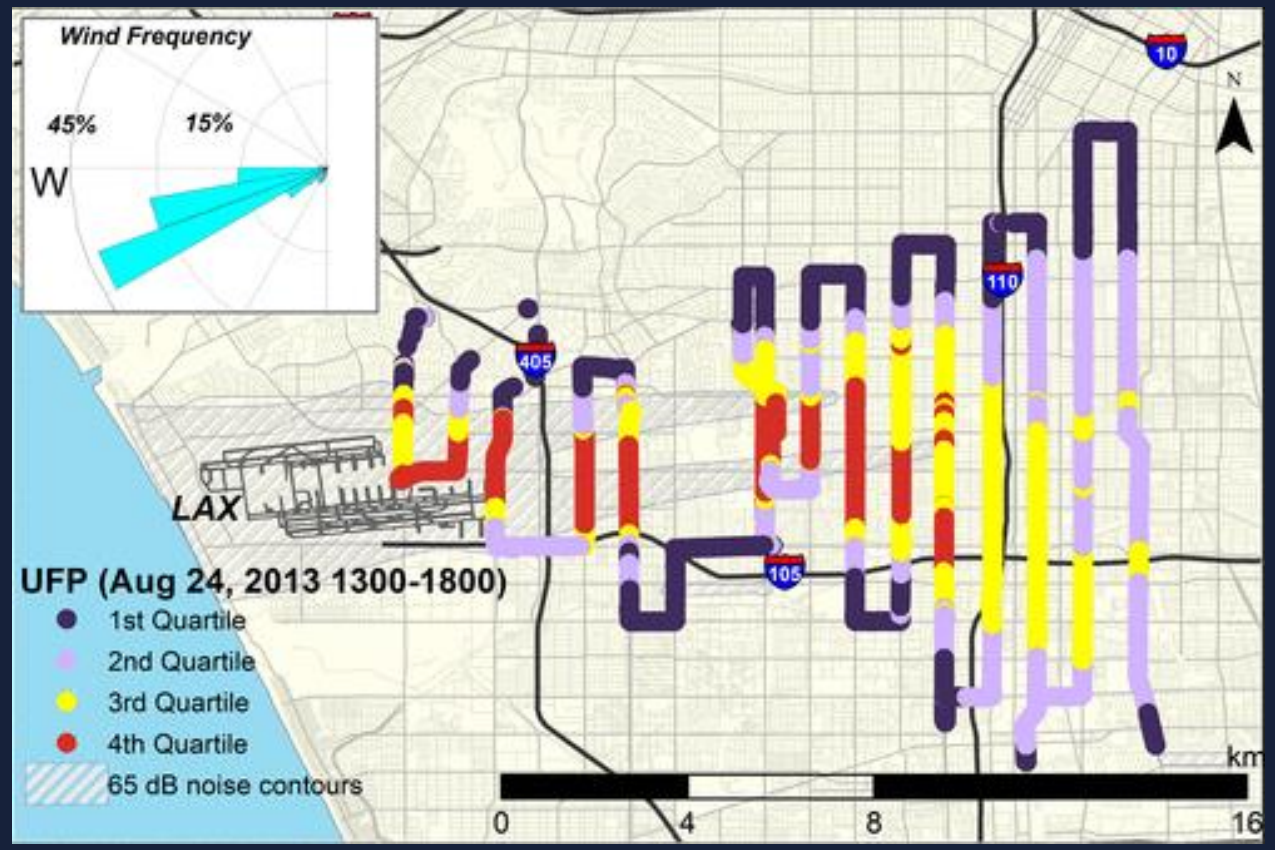
ABSTRACT: We measured particle size distributions and spatial patterns of particle number (PN) and particle surface area concentrations downwind from the Los Angeles International Airport (LAX) where large increases (over local background) in PN concentrations routinely extended 18 km downwind. These elevations were mostly comprised of ultrafine particles smaller than 40 nm. For a given downwind distance, the greatest increases in PN concentrations, along with the smallest mean sizes, were detected at locations under the landing jet trajectories. The smaller size of particles in the impacted area, as compared to the ambient urban aerosol, increased calculated lung deposition fractions to 0.7–0.8 from 0.5–0.7. A diffusion charging instrument (DiSCMini), that simulates alveolar lung deposition, measured a fivefold increase in alveolar-lung deposited surface area concentrations 2–3 km downwind from the airport (over local background), decreasing steadily to a twofold increase 18 km downwind. These ratios (elevated lung-deposited surface area over background) were lower than the corresponding ratios for elevated PN concentrations, which decreased from tenfold to twofold over the same distance, but the spatial patterns of elevated concentrations were similar. It appears that PN concentration can serve as a nonlinear proxy for lung deposited surface area downwind of major airports.

Hudda et al. 2014 https://pubs.acs.org/doi/pdf/10.1021/es5001566

Hudda et al. 2016 https://pubs.acs.org/doi/pdf/10.1021/acs.est.5b05313

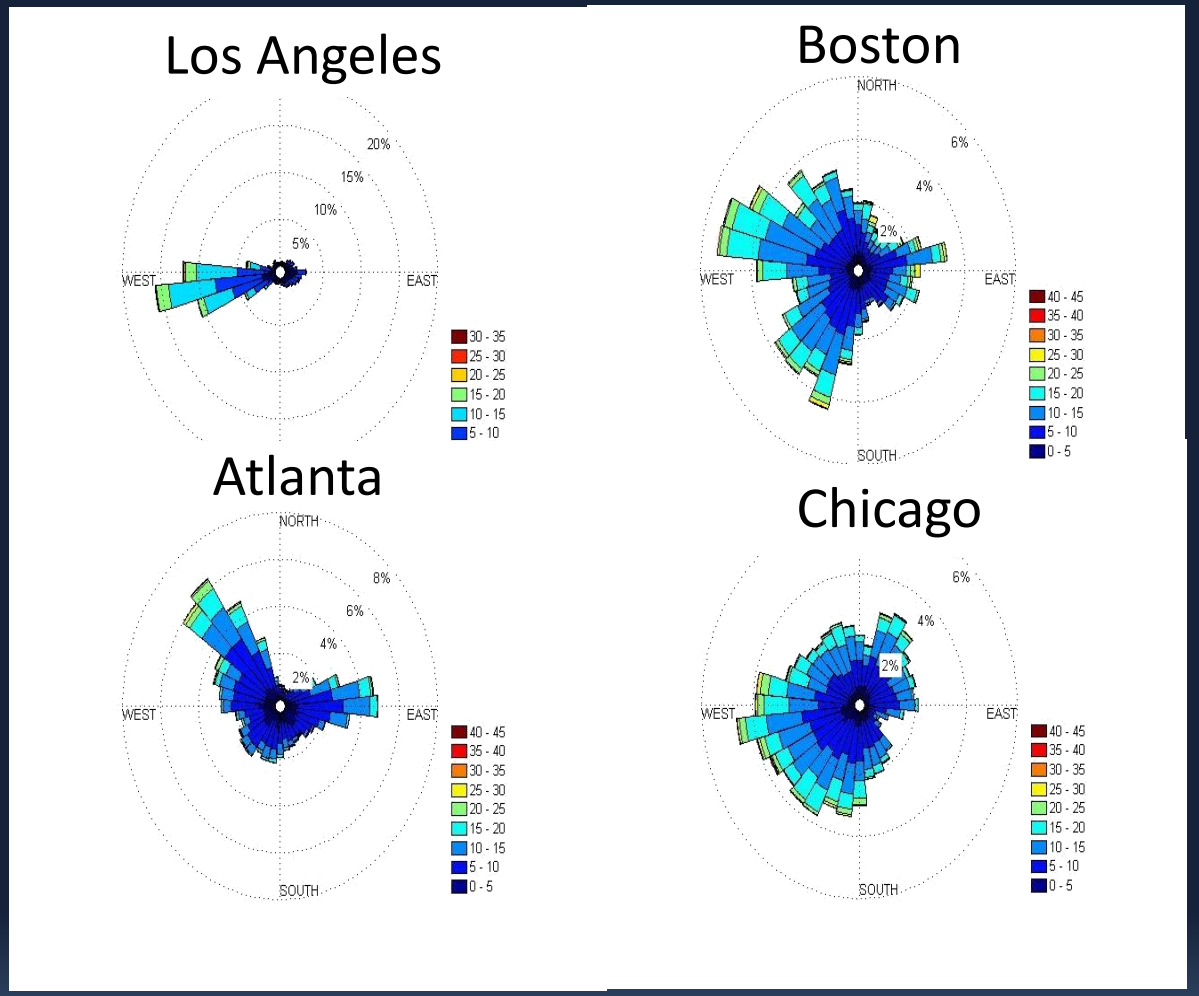
Study Setting: LAX/Los Angeles International

- A very large spatial zone of impact
- 100-900% increase in PNC extended 20 km downwind
- Concentrations increased by about 35,000 particles/cm3 over a 30-65 km^2 area



Study Setting: Unique Meteorology at LA

- 99% of daytime winds are from WSW; high constancy
- The community/communities downwind i.e., E of LAX are experiencing the impacts not intermittently but almost constantly.
- Exposure is nearly constant



Study Design

Objective

We evaluated whether ultrafine particles (UFPs) from jet aircraft emissions increase rates of PTB near LAX, i.e., within 15 km of LAX.

Methods

- ❑ Sample Population and Health Outcome
- ❑ UFP Exposure Analysis Methodology
- ❑ Covariates

Study Design

Sample Population and Health Outcome

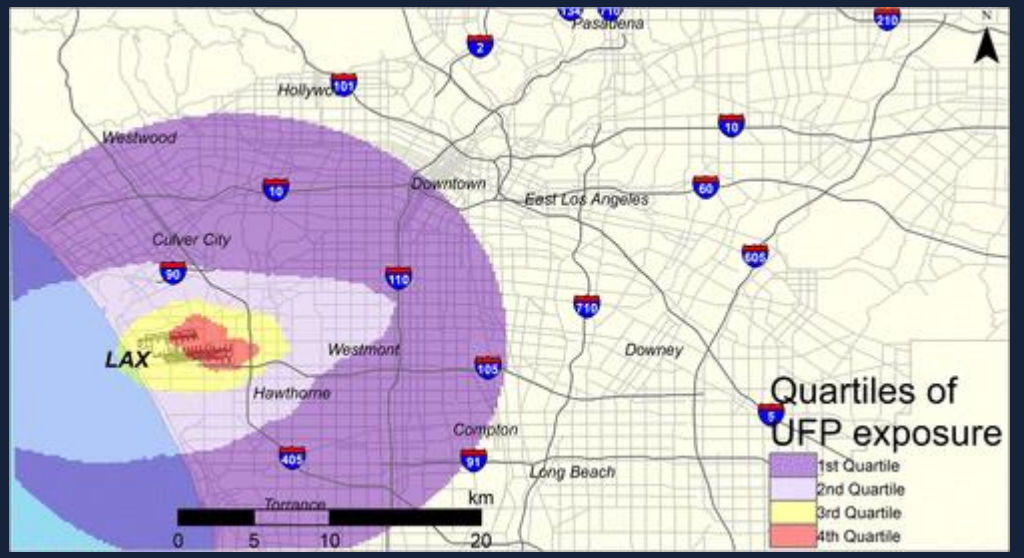
- We identified all mothers who gave birth from 2008 through 2016 while living within 15 km of LAX using birth certificates obtained from the California Department of Public Health.
- Our health outcome, PTB, was defined as a live birth occurring before 37 week gestation (yes/no).
- We excluded birth records with:
  - implausible gestational ages (<20 or >50wk, n=686),
  - implausible birth weights (<500g or >5,000g, n=1,181),
  - non-singleton pregnancies (n=6,407),
  - or missing data on any covariates (n=14,236)
- Sample size = 174,186 births

Study Design

Exposure Analysis

AERMOD dispersion model for UFPs were built and validated with spatially extensive ground-level measurements

- ❑ Arrival paths for the two parallel runways were modeled as volumetric line source
- ❑ Model predictions were compared to measurements and scaled
- ❑ Model was run January 2008 - December 2016
- ❑ Average values were computed for each month during that period at the receptor locations (1 km X 1 km grid)



Estimated UFP exposure quartiles from AERMOD results, Wing et al 2020 EHP

Study Design

Covariates

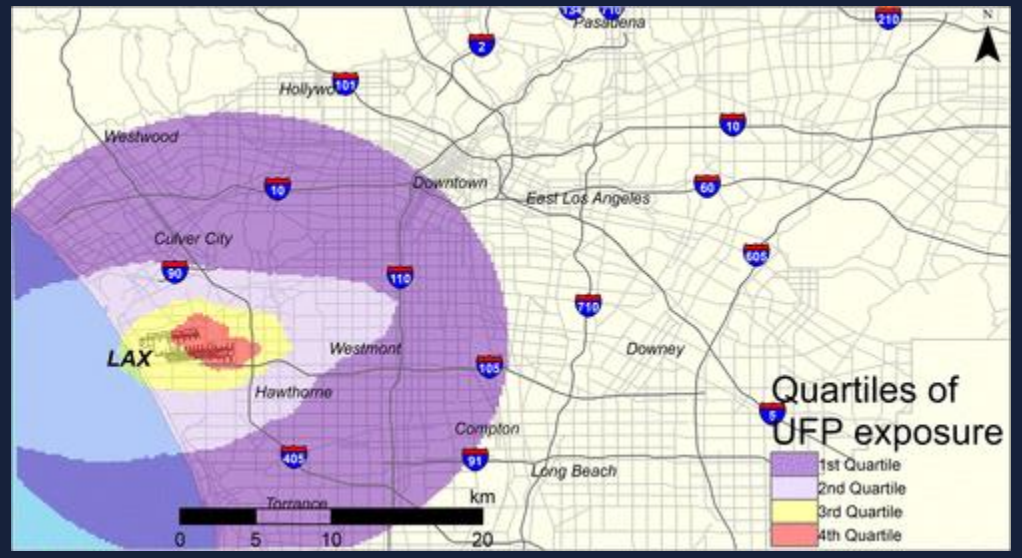
- ❑ Controlled for NO_2 concentrations as a proxy for vehicular traffic exposure
- ❑ Known PTB risk factors
- ❑ Noise (either above or below 65 dB)
- ❑ Socioeconomic status

Statistical Method

We assessed the association between quartiles of residential location-specific aircraft UFP concentrations during pregnancy and PTB using logistic regression.

Findings

- The highest quartile of exposure was associated with a 1.32 (CI: 1.27-1.39) odds ratio (OR)* in comparison with the lowest quartile.
- Controlling for covariates (demographic risk factors, traffic pollution and noise) the OR for the highest quartile was 1.14 (CI: 1.08-1.20) compared to lowest.



Estimated UFP exposure quartiles from AERMOD results, Wing et al 2020 EHP

Table 2. Adjusted odds ratios (ORs) [95% confidence intervals (CIs)]

Variable	Unadjusted model	Adjusted model 3[d]
UFP		
Quartile 1 (<5,340 particles/cc)	Ref	Ref
Quartile 2 (5,340–8,600 particles/cc)	1.17 (1.11, 1.22)	1.03 (0.98, 1.08)
Quartile 3 (8,600–14,600 particles/cc)	1.27 (1.22, 1.33)	1.08 (1.02, 1.13)
Quartile 4 (>14,600 particles/cc)	1.32 (1.27, 1.39)	1.14 (1.08, 1.20)
NO_2		
Quartile 1 (<21.8 ppb)	—	Ref
Quartile 2 (21.8–23.8 ppb)	—	1.10 (1.05, 1.16)
Quartile 3 (23.9–25.5 ppb)	—	1.11 (1.05, 1.15)
Quartile 4 (>25.5 ppb)	—	1.15 (1.09, 1.22)
Exposed to noise >65 dB CNEL	—	1.10 (1.01, 1.19)

**The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. Szumilas M. 2015 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2938757/*

Conclusion and Limitations

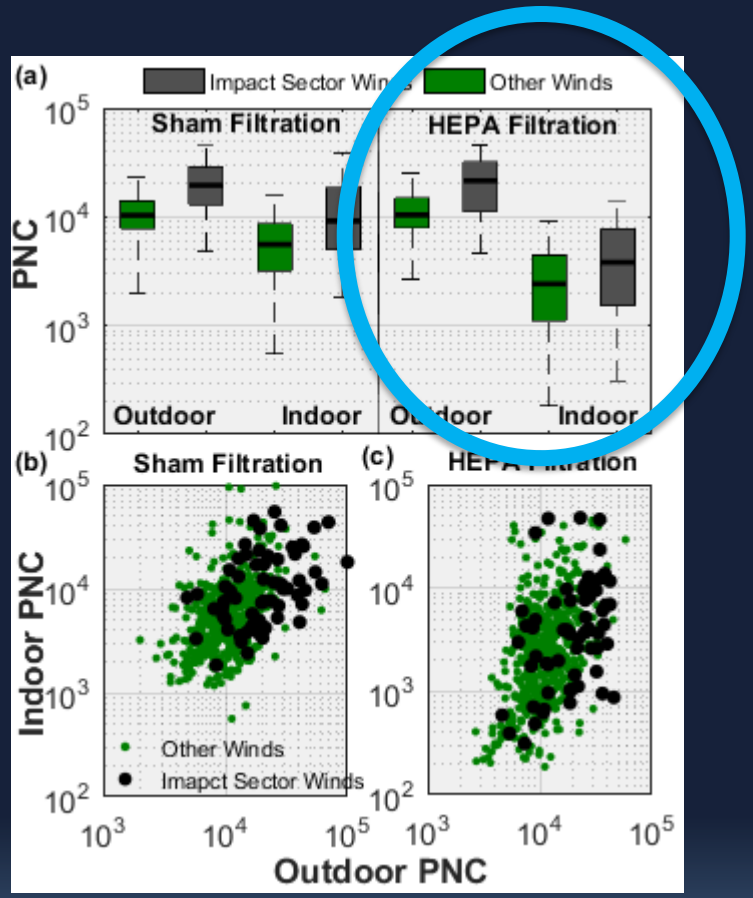
- We found in utero exposures to jet-specific UFP emissions to be associated with increased odds of PTB among mothers living within 15 km of LAX.

- Limitations:
  - A semiecological exposure assessment: we estimated UFP exposures only at the home address provided on the birth certificate, and we cannot account for time spent by mothers at work, in transit, or at other residences prior to birth.
  - We did not account for possible changes in emission factors over the 9 year study period for lack of such information

Ending on a bright note…

Filtration does reduce indoor concentrations of aviation-origin particles

Hudda et al. 2018 **https://pubs.acs.org/doi/abs/10.1021/acs.est.7b05593**



- ❑ Indoor infiltration rates of particles ~75%

  Hudda et al. 2020 https://pubs.acs.org/doi/abs/10.1021/acs.est.0c01859

- ❑ Residential concentrations of many pollutants highest/elevated when they are downwind of the airport

  Hudda et al. 2020 https://pubs.acs.org/doi/abs/10.1021/acs.est.0c01859

Acknowledgements

This work, and many associated works I refer to, were funded by **NIH/NIEHS** but do not represent the view of the institution.

Contact Information

neelakshi.hudda@tufts.edu
617-627-3522

Thank you for your attention.