COLLABORATION | COMMUNITY | EQUITY, DIVERSITY AND ANTI-RACISM | MEANINGFUL POSITIVE IMPACT | INNOVATION | SHARED LEARNING

Use, Impact & Solutions to Leaded Av-gas use in Airport Communities

Tuesday, December 10, 2024

Elena Austin, ScD
Center for Environmental Health Equity

SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

UW Team

Elena Austin
Assistant Professor
DEOHS
elaustin@uw.edu

Edmund Seto
Professor
DEOHS
eseto@uw.edu

Ningrui Liu
Postdoctoral Fellow
DEOHS
liunr24@uw.edu

Janice North
MS Student
Department of Epidemiology
JInorth@uw.edu

SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Outline of Presentation

- Research partners
- Leaded aviation gas
  - Scope of impact
  - Current knowledge
  - WA State problem statement
- Solution oriented next steps
- Discussion

Partners

Collaborated on the work presented here

- KCIACC – initial request for data support
- SeaTac Airport Community Coalition for Justice – research translation
- UW CEHE – coordination with Elena Austin and Janice North
- WA agencies like DOH – data layers
- Seattle & King County Public Health
- WA State Legislators
- US EPA – national data sources and regional input

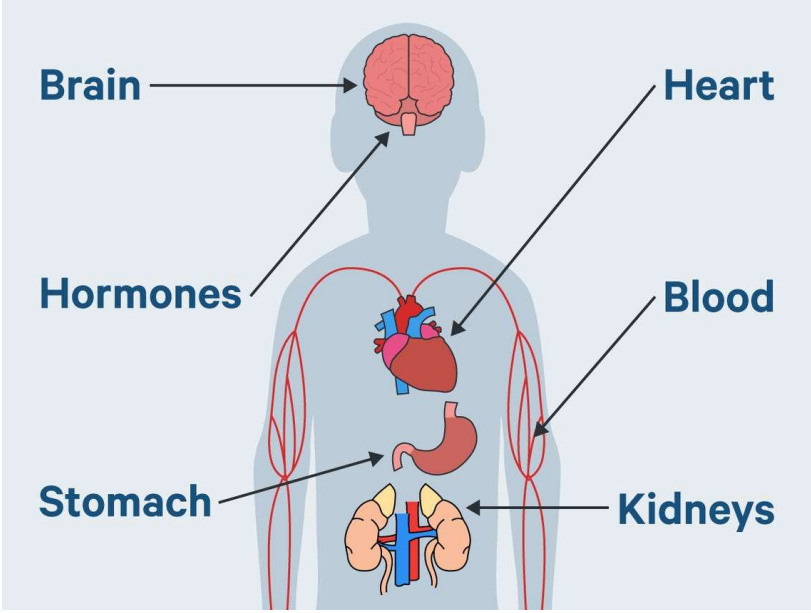
Background: leaded aviation fuel near airports

- Small piston-engine planes (2-10 passengers) are the largest source of lead in the air, since leaded gasoline for on-road vehicles was banned in 1996 through the Clean Air Act.
- A 2023 EPA determination states that emissions from these planes pose environmental and health risks to communities surrounding airports.

Pictured: a piston-engine aircraft (PEA)

Health impacts of lead on children

- No safe level of lead in the blood, any detectable blood lead levels (BLLs) are bad (PEHSU, 2024).
- Associated with lower IQ, ADHD, hearing loss, damaged nerves, impaired cell and bone growth, kidney failure, underperformance in school, and higher risk of high blood pressure 50 years later (WHO, 2023).
- Lifelong burden—bones act as a reservoir for lead even after BLL decline (PEHSU, 2024).

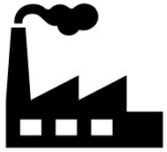


0

Sources of lead in environment (Zulfigar, et al. 2019)

Lead Pipes & Fixtures

Contaminated Soil



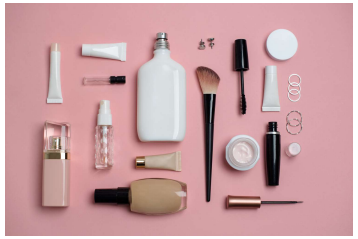
Industrial Point Sources

Imported Home Goods

Damaged Legacy Lead Paint

Foods & Spices

Some Toys



Some Cosmetic Products

Leaded Aviation Gas

SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Slide 7

0 [@Janice North] Source?
Elena Austin, 2024-05-01T21:10:20.172

JN0 0 yes, I will add all sources and reference page later this afternoon!
Janice North, 2024-05-01T21:27:19.657

JN0 1 right now they are in the note section of each page.
Janice North, 2024-05-01T21:27:31.126

0 2 Oh great, I didn't see that.
Elena Austin, 2024-05-01T22:12:49.262

JN0 3 just got back from a meeting. Working on the slides now!
Janice North, 2024-05-01T22:43:02.314

Enviromental justice concerns

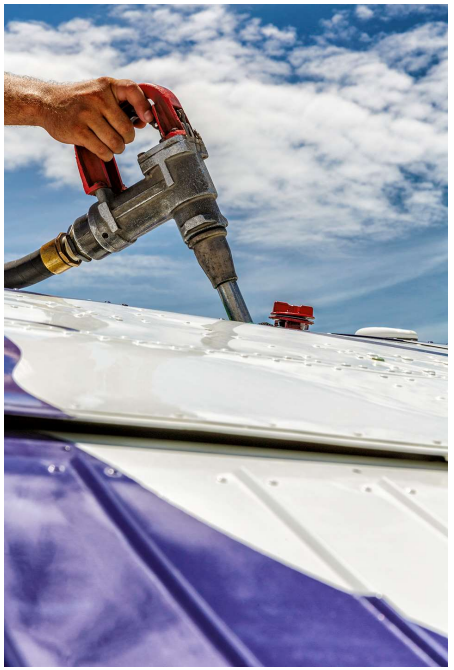
Lead exposure disproportionately impact low-income, BIPOC communities. (Gochfeld & Burger, 2011)

- Historical zoning practices
- Older housing stock with lead-based paint
- Proximity to industrial activities
- Nutritional deficiencies such as iron, calcium, magnesium, and zinc promote lead absorption

What is leaded aviation fuel (AvGas)?

A specialized fuel used to power piston engine aircraft (FAA, 2019).

- What is Tetraethyl Lead (TEL)?
  - an organic compound that contains lead and can boost octane—a measure of the performance of a fuel and its ability to resist detonation, or "knock."
- Why is TEL banned in automobile gas but not yet for the use in avgas?
  - Lack of operationally safe, cost-effective alternative
  - Complex process of adapting aircraft engines and infrastructure to accommodate unleaded fuels.

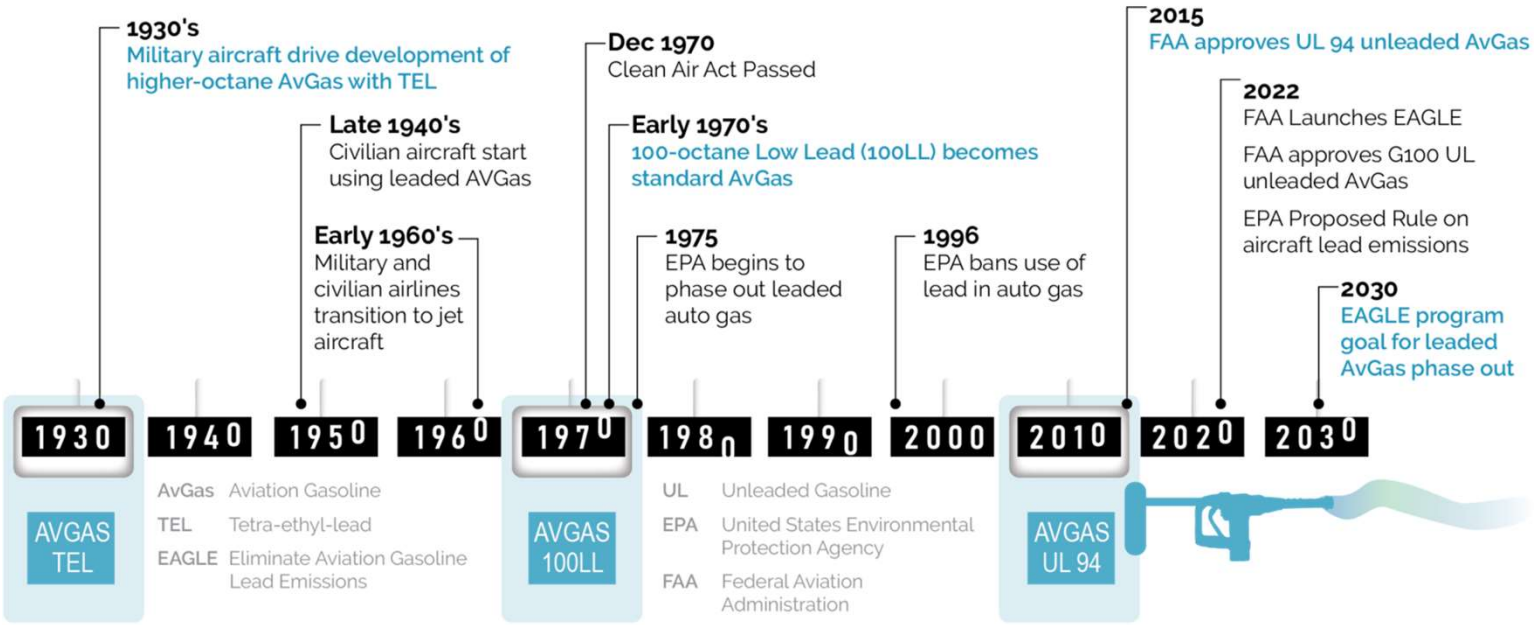


U.S. Environmental Protection Agency (EPA) Determination 2023

In 2023, EPA determines that lead emissions to air from certain aircraft engines "cause or contribute to air pollution which may reasonably be anticipated to endanger public health and welfare."

However, it does not authorize any action by state or local agencies to regular leaded aviation fuel and ensure its elimination.

The evolution of aviation gas (ESA, 2023)



Legislative effort in WA State: House Bill 1554

H.B.1554 was introduced during introduced during the 2023 session to expedite the transition to the use of unleaded aviation gasoline by:

- Prohibiting the sale and distribution of 100LL aviation fuel in phases beginning in 2026,
- With additional prohibitions in 2028, and
- With a statewide ban effective in 2030.

Industry reactions

Example: Aircraft Owners and Pilots Association (AOPA) pushed back on H.B.1554 banning 100LL sales (Britton, 2023).

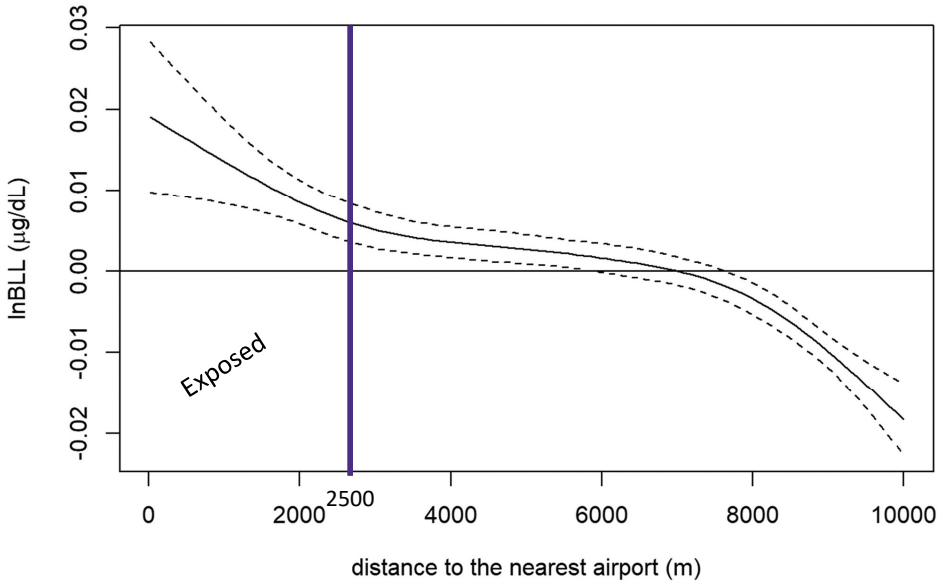
- AOPA concerns:
  - Premature phasing out before unleaded 100-octane replacement is widely available)
  - Economic impacts: increased cost associated with transitioning to unleaded aviation gasoline
  - Safety issues (engine failure attributed to improper fueling at Reid-Hillview Airport in Santa Clara, CA.
- Results
  - Removal of leaded fuel prohibitions, compliance-related fines for airports, Washington Department of Ecology oversight, and related mandates targeting airports
  - What remains in the bill: required lead-related education and outreach campaign targeting airport **operators and pilots of piston-engine aircraft**

Research on toxic airborne lead emitted from piston-engine aircraft (PEA)

- Leaded aviation fuel is used in nearly **170,000 PEAs across 20,000 airports**. Emissions from these airplanes account for about **70% of lead released** into the atmosphere (EPA, 2019).
- 14,000 blood lead samples of children (≤5 y of age) residing near Reid-Hillview Airport increased (on average 0.72 µg/dL) in proximity to and **downwind of the airport**, and with the volume of PEA traffic and quantities of avgas sold at the airport. The increase in BLL estimated to be 50% of the increase associated with water exposures in Flint, MI (Zahran et al, 2023)
- Elevated BLLs were detected near Santa Monica airport, along with a gradient in lead concentration associated with **distance from the airport**, run-up times, hourly activity patterns of PEA, multi-engine vs. single-engine aircraft activity, and the lead concentration in avgas used at the airport (Carr, E. et al, 2011).

Association between Residential Distance to Airport and Blood Lead Levels in Children under 6 Living in North Carolina, 1992–2015

Robust Findings without Accounting for Wind Direction



Dose-response relationship between child blood lead levels (BLL) and residential proximity to airport. Result of the relationship between the natural logged blood lead levels of children 6 years of age and below living in North Carolina (n = 934,602) who screened for lead between 1992 and 2015 and the distance from the child's house to the nearest airport (in meters) is given.

The results is based on a general additive model fit with lnBLL as response and distance included as a cubic spline while controlling for

- child's age
- sex at birth
- self-reported race
- Medicaid enrollment
- year of test
- season

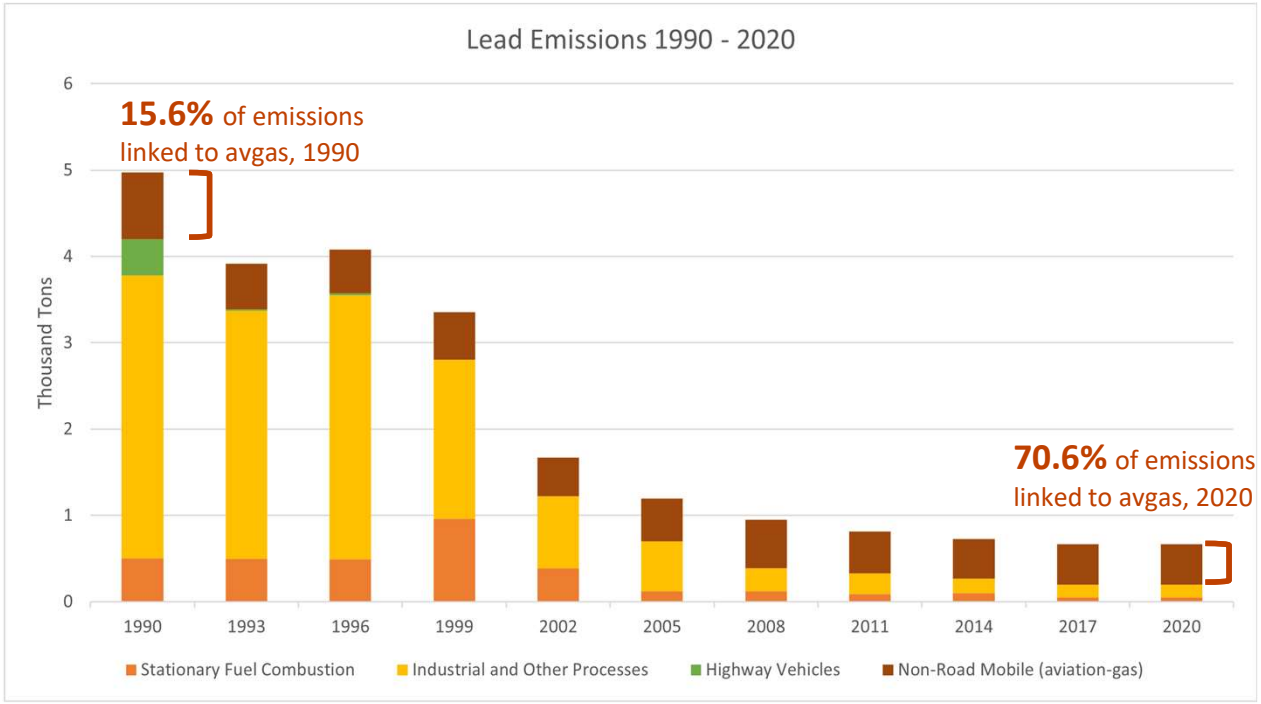
The estimates from the model were all statistically significant with p-values less than 0.001.

https://doi.org/10.1289/EHP14362

The average BLL for "exposed" children was 1.8% higher compared to those in the control group

SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Lead Emissions in the U.S. between 1990 and 2020



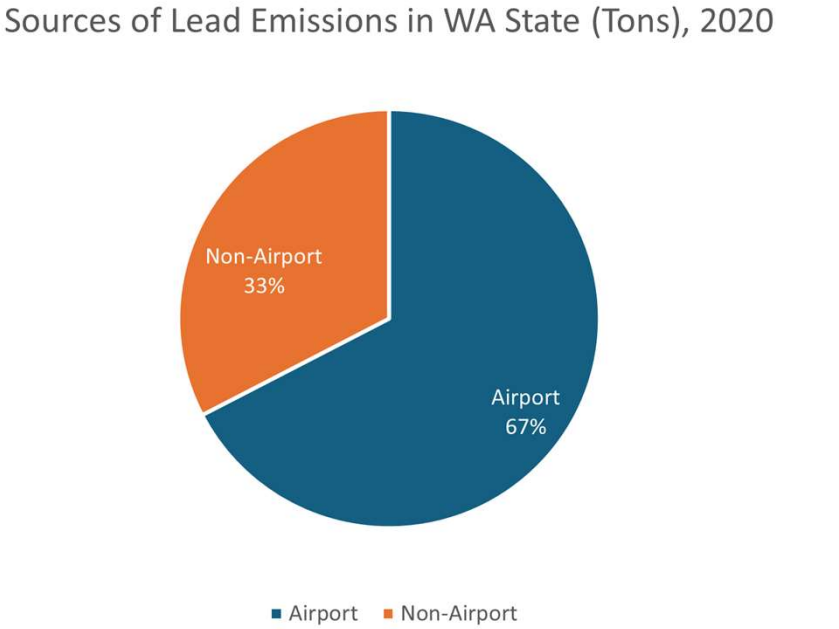
SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Source: Out Nation's Air: Status and Trends Through 2021

Airport lead emissions in Washington State

Facility Type	WA Facilities (Count)	WA Facilities (%)	Emissions (Tons)	Emissions (%)
Airport	155	**66%**	5.97	**67%**
Non-Airport	79	**34%**	2.89	**33%**
Total	234	100%	8.86	100%

Airports make up **66%** of all facilities emitting lead in Washington State, and they are responsible for **67%** of the airborne lead emissions in the state.



SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Source: Out Nation's Air: Status and Trends Through 2021

Demographic summary of Washington residents living within 1km of airports

- According to WA DOH (2024) data notes on the Washington Tracking Network, a total of 132,689 individuals (1.79% of WA state residents) live within the 1km buffer zones around WA airports.
- Within the buffer zones, there are 52 schools and 29 childcare centers.

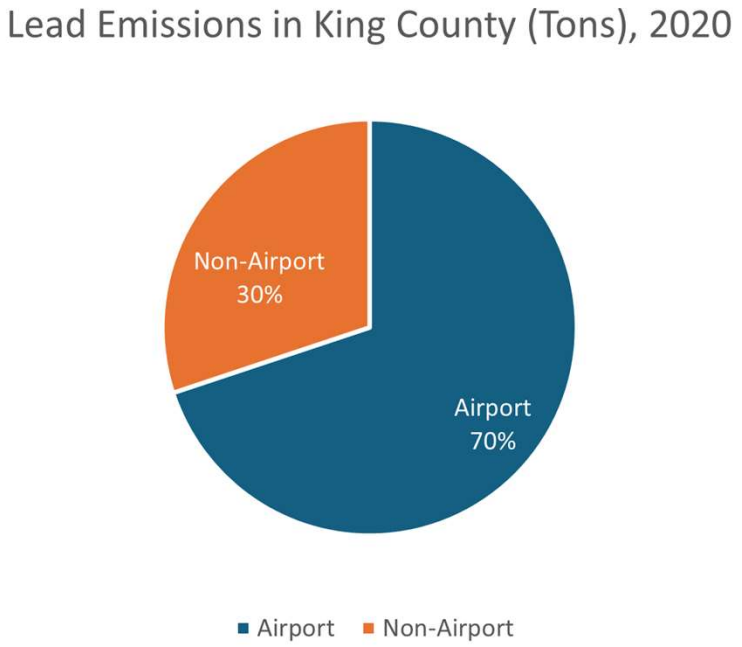
	1km Airport Buffer n (%)	Washington State n (%)
Total Population	132,689	7,404,107
Population 5 and under	5,867 (4%)	454,364 (6%)
People of Color	47,509 (36%)	2,330,162 (32%)
Foreign Born	26,190 (20%)	1,056,534 (14%)
Total Families	28,528	1,841,954
Families Living Below Federal Poverty Level	1,508 (5%)	127,119 (7%)
Total Households	64,262	2,848,396
Limited English-Speaking Households	2,515 (4%)	108,151 (4%)

Source: WADOH (2024). Data Notes for the Leaded Aviation Fuel Exposure Overlay on the Washington Tracking Network (WTN) Information by Location Tool (IBL).

Airport lead emissions in King County

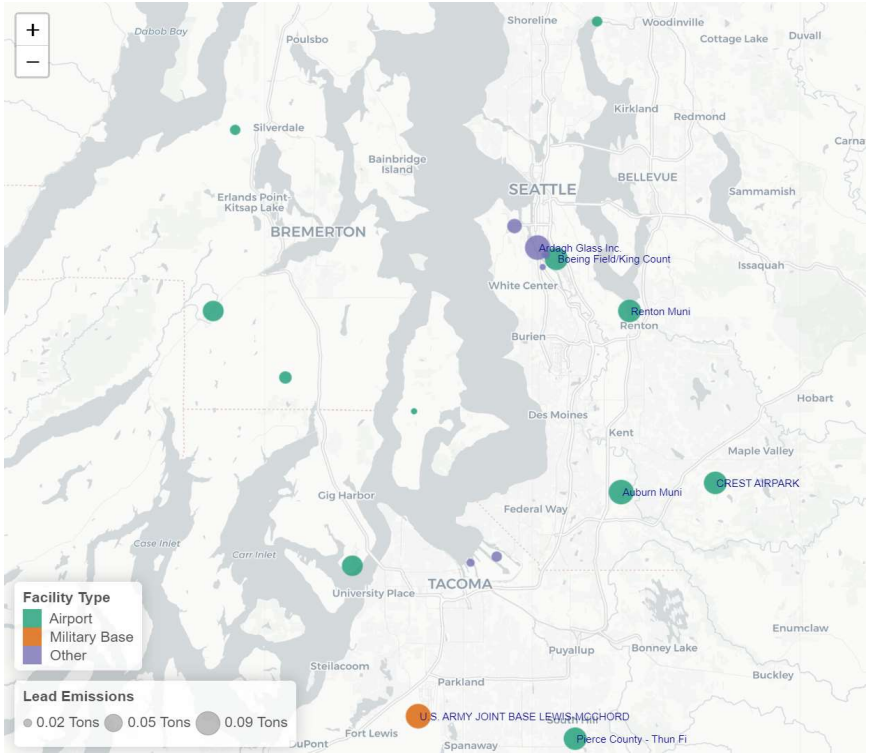
Facility Type	KC Facilities (Count)	KC Facilities (%)	Emissions (Tons)	Emissions (%)
Airport	15	58%	1.23	70%
Non-Airport	11	42%	0.53	30%
Total	26	100%	1.76	100%

Airports comprise **58%** of all facilities emitting lead in King County, and they are accountable for **70%** of the airborne lead emissions in the county.



Source: Out Nation's Air: Status and Trends Through 2021

King County facilities with the highest lead emissions, 2020



Site Name	Facility Type	Emissions (Tons)
Ardagh Glass Inc.	Glass Plant	0.42800
Auburn Muni	Airport	0.36631
Boeing Field/King Count	Airport	0.27628
CREST AIRPARK	Airport	0.25727
Renton Muni	Airport	0.23846

https://gispub.epa.gov/air/trendsreport/2022/#home

King County International Airport - Boeing Field (KCIA)

Airport facts

- One of the busiest general aviation airports in the U.S.
- Proximity to Downtown Seattle
- Serve small commercial passenger airlines, cargo carriers, private pilots, corporate jets, helicopters, and military aircraft

https://kingcounty.gov/en/dept/executive-services/transit-transportation-roads/airport


WHAT
CAN
WE
DO?

Primary intervention (adapted from EPA and PEHSU resources)

Removal of lead hazards from the environment before a child is lead exposed.

- Identify families and patients who could be at risk, including low-income families living within 1000 m from nearby airports, to identify lead hazards before moving into a home.
- Educate parents on common child behaviors (e.g., hand-to-mouth) that can increase their risk of lead exposure, with special attention given to children with pica.
- Educate families on sources of lead.
- Ban or impose restrictions on the use, sale, distribution, dispensing, and general availability of leaded fuel.
- Provide filtration/indoor air quality solutions.

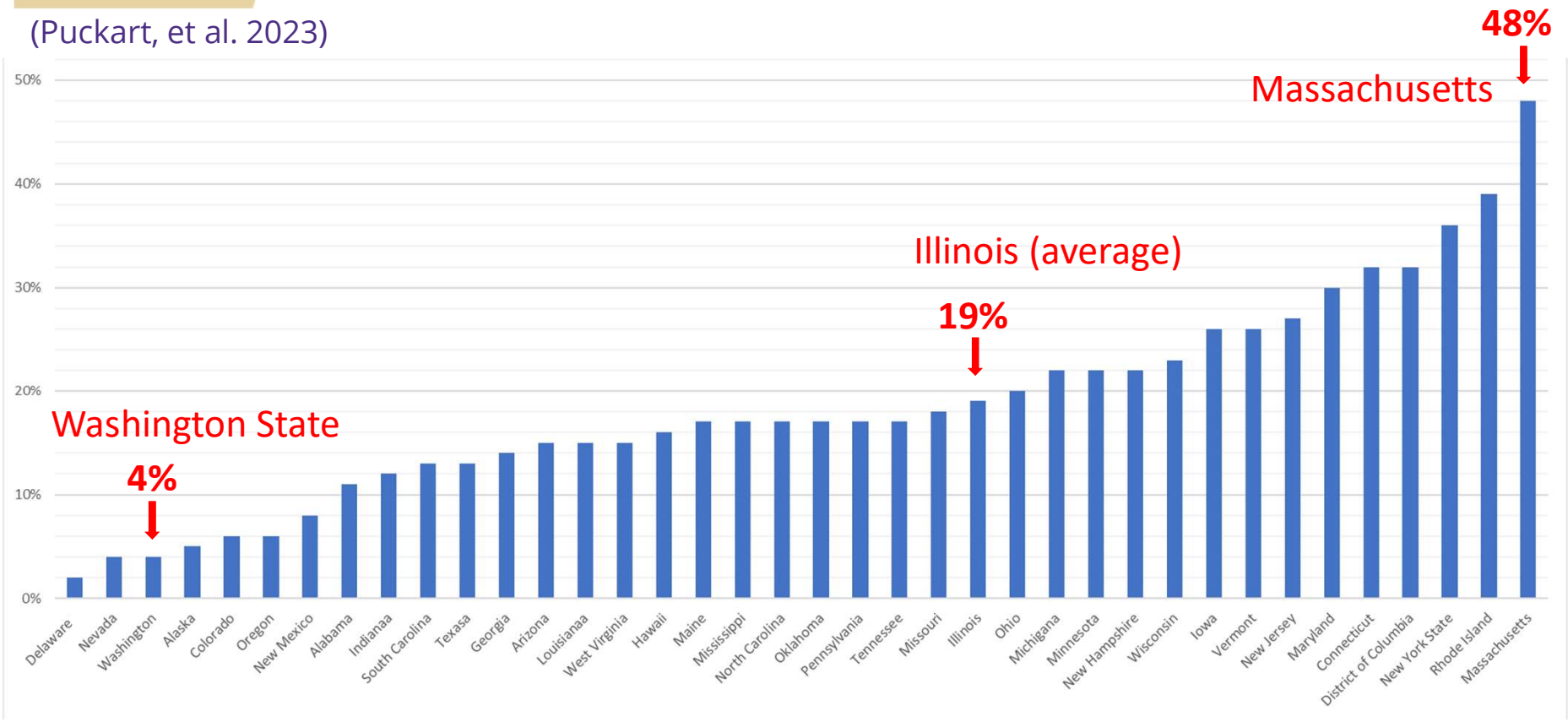
Secondary intervention (adapted from EPA and PEHSU resources)

Screening, testing, and follow-up care and referral for children who live near airports (e.g. 2500 m) who may already be exposed to lead

- Screening
  - Conduct risk assessments on all children at key developmental stages, including 6, 9, 12, 18, and 24 months, and 3, 4, 5, and 6 years of age to determine potential sources of lead exposure.
- Blood lead test
  - Require universal blood tests on children 12 and 24 months on Medicaid or those living within 1000 meters of an airport.
  - Test all children in the same household if BLL is elevated for one of the children.
- Identify high-risk children with multiple disadvantaged characteristics for targeted screening, testing, and social services. They include children living within 2500 meters from an airport who are also:
  - low income
  - recent immigrants, children of immigrants, international adoptees,
  - with oral behaviors (or pica)
  - living in housing built before 1978, especially those built before 1950

Proportion of Children Tested for Blood Lead Levels in 2017-2018, by State

(Puckart, et al. 2023)



Routes of Exposure for Children in Proximity to Leaded av-gas Sources

- **Contaminated Soil**
  - Bulk tank leakage
  - Spills

- **Airborne Exposures**
  - Ground Idling
  - Landing/Takeoff
  - Dust Suspension

Research suggests airborne exposures are likely

- Downwind gradients in blood lead
- Exposures up-to 2500 meters from the airport
- Increased understanding of landing/takeoff exposures

Contaminated soil must also be identified and remediated.

Ettinger A. S. (2022). Invited Perspective: Identifying Childhood Lead Exposure Hotspots for Action. Environmental health perspectives, 130(7), 71301. https://doi.org/10.1289/EHP10916

Sammy Zahran, Christopher Keyes, Bruce Lanphear, Leaded aviation gasoline exposure risk and child blood lead levels, PNAS Nexus, Volume 2, Issue 1, January 2023, pgac285, https://doi.org/10.1093/pnasnexus/pgac285

Carr, E., Lee, M., Marin K., Holder C., Hoyer M., Pedde M., Cook R., Touma J. (2011). Development and evaluation of an air quality modeling approach to assess near-field impacts of lead emissions from piston-engine aircraft operating on leaded aviation gasoline. https://www.sciencedirect.com/science/article/pii/S1352231011007333

Soale AN, Callender R, Guignet D, Shadbegian R, Miranda ML. Association between Residential Distance to Airport and Blood Lead Levels in Children under 6 Living in North Carolina, 1992–2015. Environmental Health Perspectives. 2024 Aug 9;132(8):087701.

Particulates from aircraft

Understanding the health effects of jet pollution around Sea-Tac Airport

A policy brief for the Washington State Legislature

Summary

Communities underneath and downwind of jets landing at Seattle-Tacoma International Airport are exposed to a type of ultrafine particle pollution that is distinctly associated with aircraft, according to a 2019 University of Washington (UW) study that is the first to identify the unique signature of aircraft emissions in Washington.

The finding comes from the two-year Mobile ObserVations of Ultrafine Particles (MOV-UP) study funded by the Washington State Legislature and led by the UW Department of Environmental & Occupational Health Sciences and the Department of Civil and Environmental Engineering.

The MOV-UP study examined the air-quality impacts of aircraft traffic on communities located

The discovery creates opportunities to investigate the health effects of aircraft-related pollution, how different neighborhoods are impacted by it and specific interventions to reduce people's exposure to these pollutants.

Previous studies have linked exposure to ultrafine pollution particles to breast cancer, heart disease, prostate cancer and a variety of lung conditions.

This policy brief describes some of the remaining knowledge gaps about aircraft-related pollution.

It also proposes next steps that state legislators can take to better understand the health impacts of ultrafine particle pollution and to protect the health of people who live and work in the vicinity of Sea-Tac Airport.

- Ultrafine particles (UFP) are emitted from both traffic and aircraft sources.
- Total concentration of UFP (10 - 1000 nm) did not distinguish roadway and aircraft features.
- There are key differences in the particle size distribution and the black carbon concentration for roadway and aircraft features.
- Fixed site monitoring confirms that aircraft landing activity is associated with a large fraction of particles between 10-20 nm.

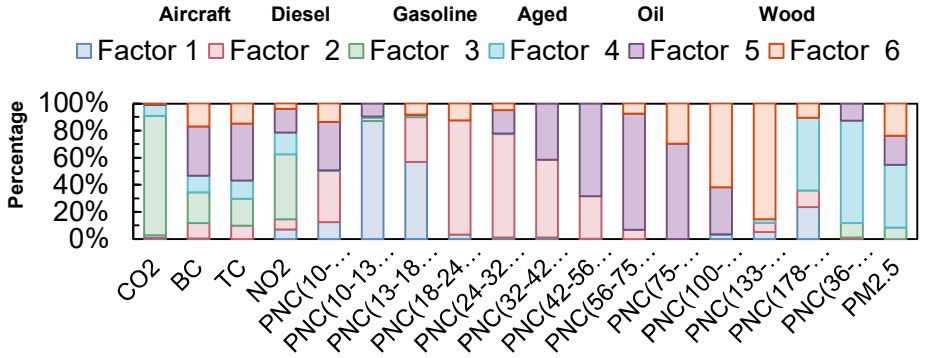
MOV-UP Project Website
https://deohs.washington.edu/mov-up

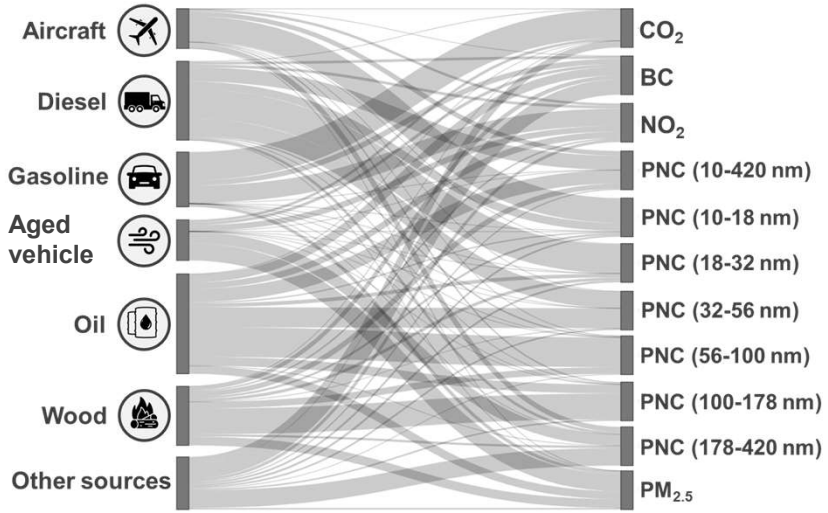
Source-specific exposure

- **Source contributions for Puget Sound ambient air pollutants**

Pollutant	1st source	2nd source
CO_2	Gasoline (75%)	Aging (8%)
BC	Oil (22%)	Gasoline (14%)
TC	Oil (29%)	Gasoline (14%)
NO_2	Gasoline (44%)	Oil (16%)
PNC		
Total (10-420 nm)	Diesel (37%)	Oil (35%)
10-18 nm	Aircraft (64%)	Diesel (20%)
18-32 nm	Diesel (76%)	Oil (10%)
32-56 nm	Oil (52%)	Diesel (43%)
56-100 nm	Oil (77%)	Wood (17%)
100-178 nm	Wood (67%)	Oil (23%)
178-420 nm	Aged (38%)	Aircraft (15%)
$PM_{2.5}$	Aged (45%)	Wood (23%)

Liu et al. (2024)





HEPA Filtration Solutions – Example 1

Airport, Asthma and Air Quality Study

Our aims are to test whether indoor **HEPA filtration** will have the following benefits for residents living near the Sea-Tac Airport (within 10 miles):

1. **Improve indoor air quality**
2. **Reduce asthma burden** (asthma symptoms, clinic utilization, sleep quality) on children

www.deohs.Washington.edu/aaa-study

AAA Impact – Community Training

Community Health Workers

Community Partners

- African Community Housing & Development
- Cultivate South Park
- Lutheran Community Services Northwest
- Villa Comunitaria

As of the end of November 2024,

- **94 people** with asthma have successfully enrolled in the CHW asthma education intervention,
- 44 have completed the full intervention program,
- **23 children ages 6-12 years old have enrolled in the research study**, and
- 4 community partners have trained CHWs serving clients.

AAA Outcomes – Asthma Education

Completion of the 3-month CHW Asthma Education Program improved health:

These improvements included:

- An average of 7.5 more symptom free days per month (46% improvement),
- Fewer nighttime awakenings (64% improvement),
- Decreased use of "rescue" medications (11% improvement),
- An average of 4 fewer asthma related sick days per month (93% improvement).

Improvement measures were based on questionnaires completed at the start and end of the program.

"If one little thing changes and the child's asthma improves, it brings a smile to my face. Seeing the confidence clients now have is amazing."

Maria Rodriguez, Community Health Worker
Public Health Seattle & King County

Public Health
Seattle & King County

Healthy Air, Healthy Schools

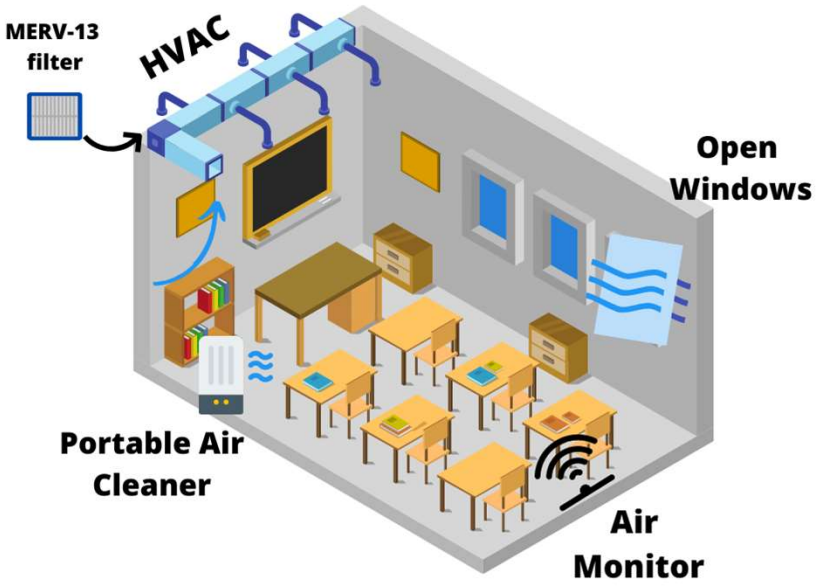
Study published in *Atmoshpere*

- Evaluate **current** ventilation systems ability to remove particles and identify potential benefit of **portable air cleaners**

- Describe the infiltration rates of **fine** and **ultrafine** particles by origin
  - Aircraft, traffic, and wildfire smoke

Communicate the study results to all study partners

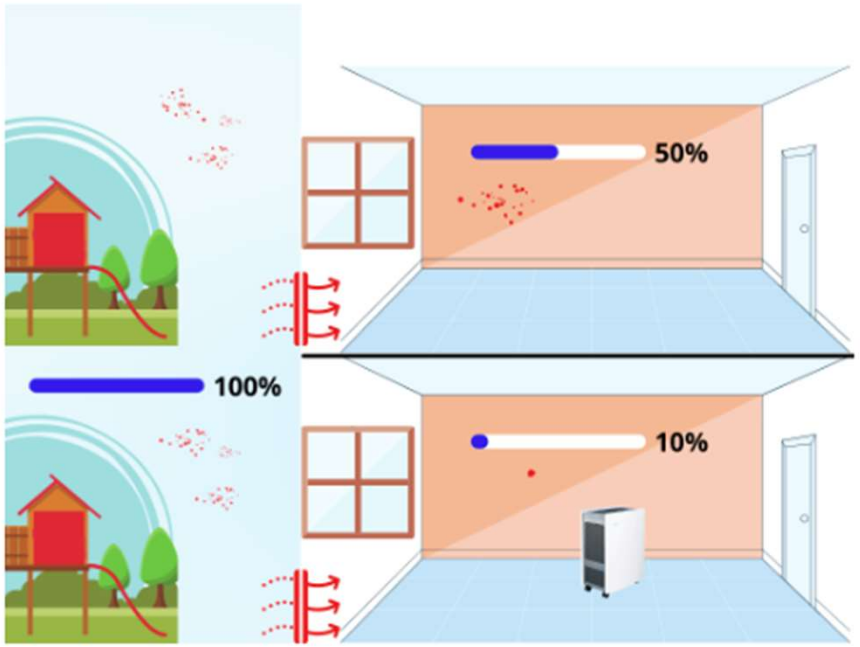
- Legislators
- Cities of Burien, Des Moines, Normandy Park, SeaTac
- Highline and Federal Way School Districts
  - Teachers, administrators, parents



Study results: Carmona N, Seto E, Gould TR, et al. *Atmosphere*. 2022;13(10):1623. doi:10.3390/atmos13101623

School Based Interventions

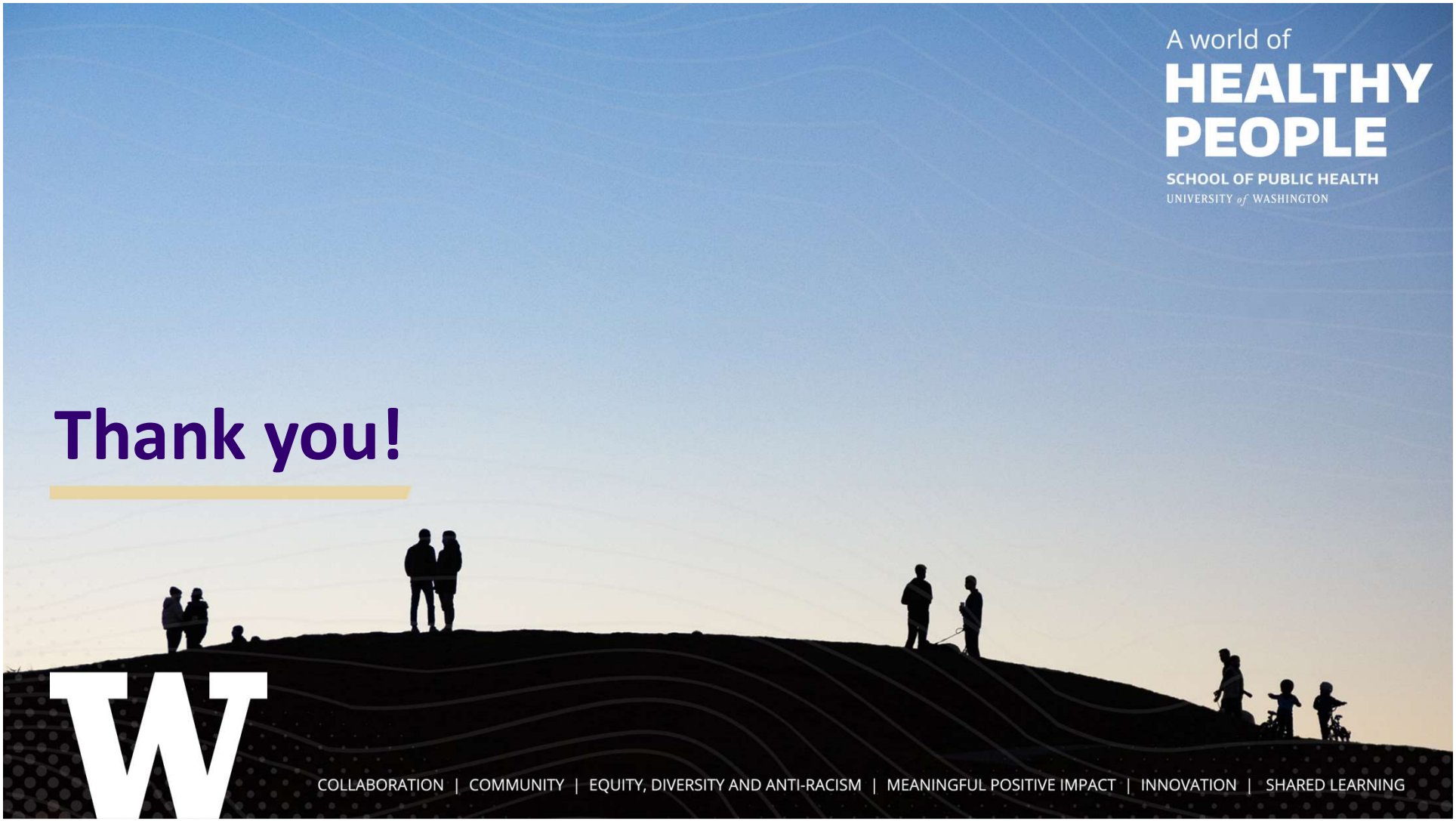
Overall, using portable HEPA filter units could reduce classroom concentrations of ultrafine particles by approximately 70%, depending on the age of the school building and other characteristics, according to the study's models.



Visualizing the impact of outdoor air pollution on A) classrooms under standard ventilation conditions and B) classrooms with a HEPA filter intervention.

ENVIRONMENTAL & OCCUPATIONAL HEALTH SCIENCES
SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Discussion: Focus priorities and need for additional data/information


A world of
HEALTHY PEOPLE
SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON
Thank you!
COLLABORATION | COMMUNITY | EQUITY, DIVERSITY AND ANTI-RACISM | MEANINGFUL POSITIVE IMPACT | INNOVATION | SHARED LEARNING