Results and Impacts of the FRESSCA-Mujeres Project

November 14, 2025

Biomonitoring California Scientific Guidance Panel Meeting

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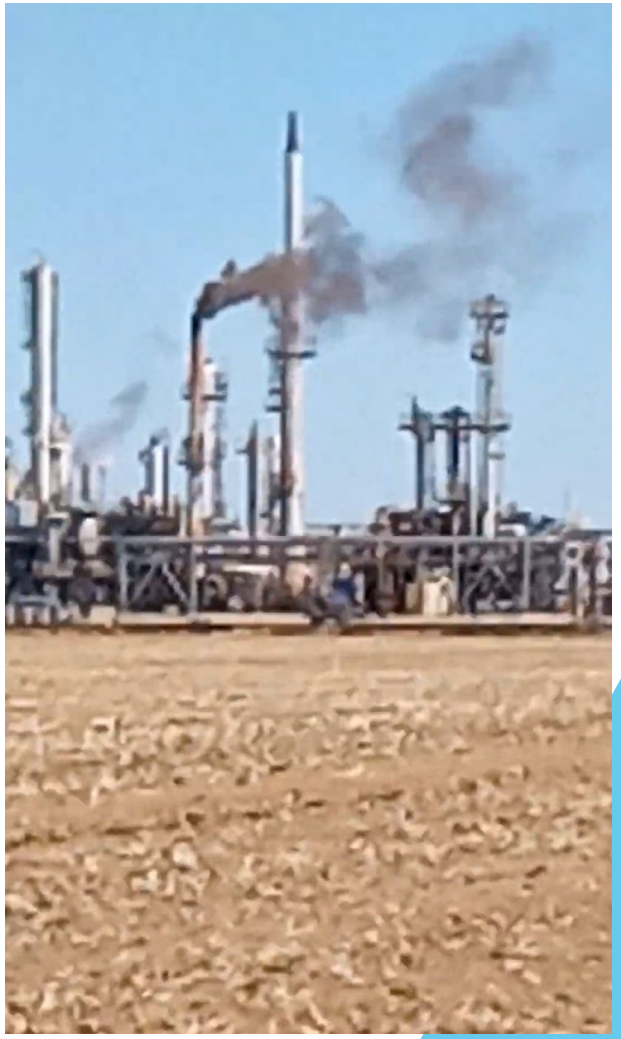
Overview

- Study background
- Intervention analysis
- Biomonitoring results
- Community impacts and perspectives
- Next steps

Study background



Project goals

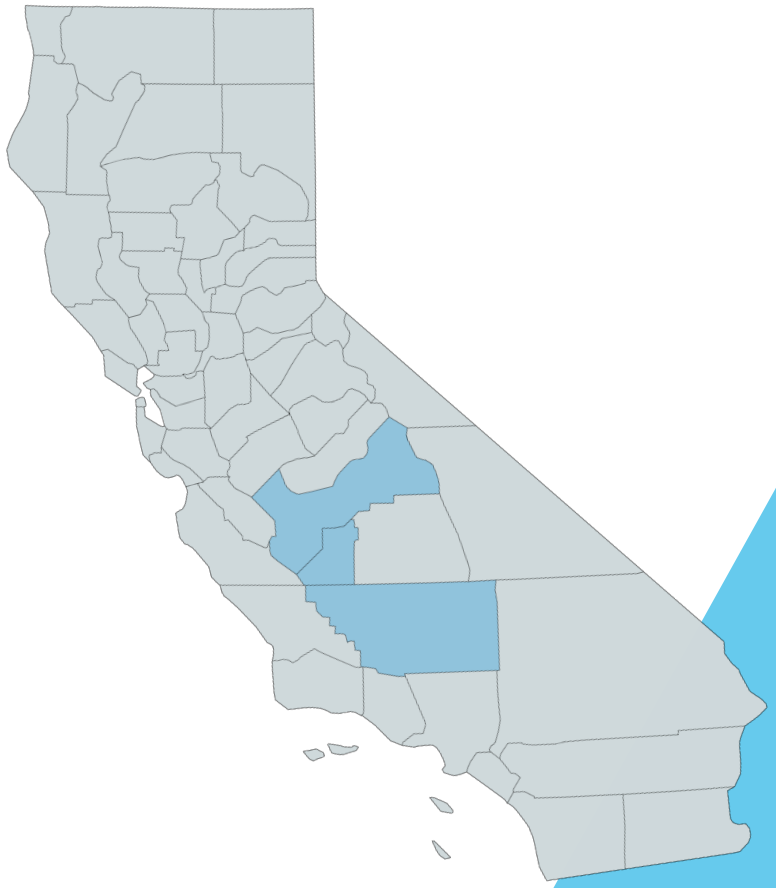
FRESSCA
AIRE LIMPIO EN CASA

Develop an affordable air filtration intervention for swamp coolers

FRESSCA MUJERES AIRE LIMPIO EN CASA

Evaluate effectiveness of air filtration interventions at reducing in-home air pollution exposures

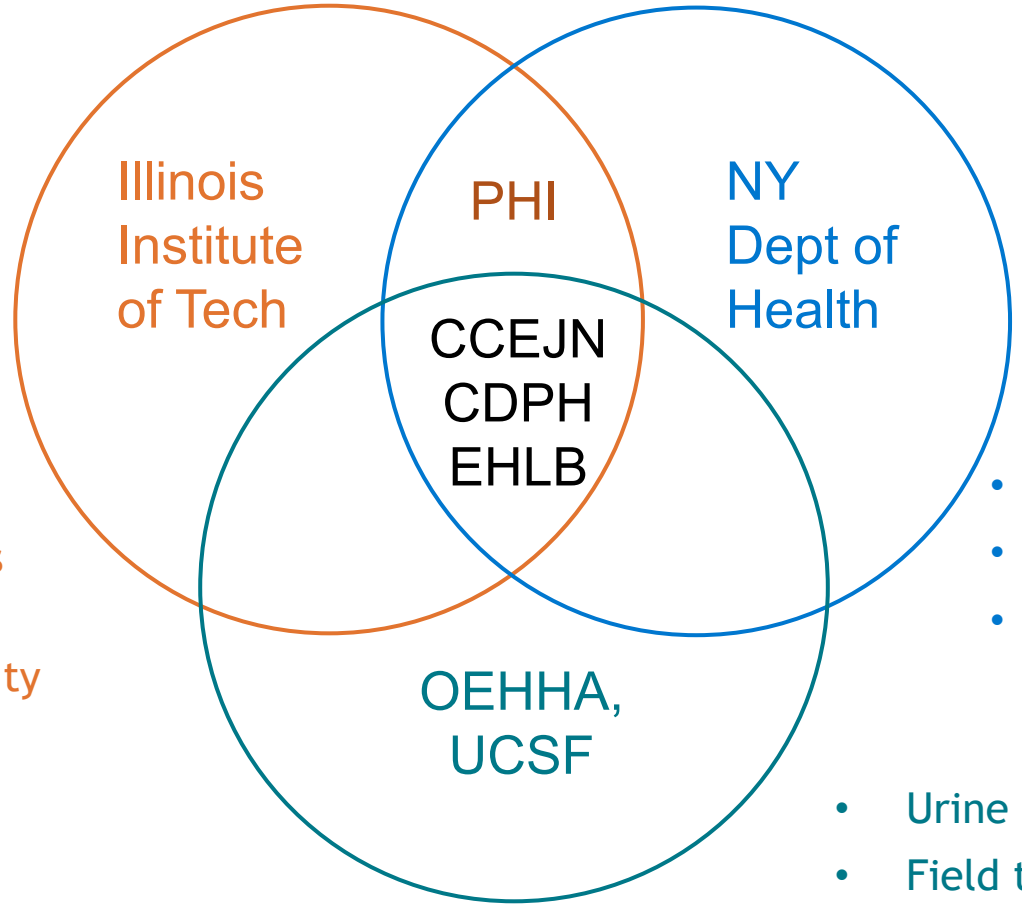
Learn more about **female agricultural workers'** exposures to air pollution in the Central Valley



Project overview - three funding sources created our interdisciplinary team

FRESSCA (US EPA)

- DIY filter testing
- $PM_{2.5}$ sensors
- Passive PM samplers
- Results return & community air quality meetings



FRESSCA-Mujeres (CA Breast Cancer Research Program)

- Air measurements of PAHs, metals, VOCs
- Urine biomarkers of stress
- Saliva telomere length

FRESSCA-Mujeres (OEHHA)

- Urine measurements of PAHs, metals, VOCs
- Field team & support for both other components
- Results return & community meetings for biomonitoring

Nayamin Martinez, CCEJN
Gina Solomon, PHI
Co-Principal Investigators

Project overview (cont'd)

FRESSCA AIRE LIMPIO EN CASA

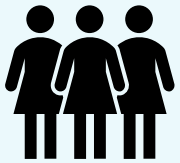
- ✓ Conducted a pilot study in 2022
- ✓ Enrolled 25 homes from Kern and Fresno Counties

- ✓ Installed PurpleAir (PA II) monitors inside and outside of the homes
- ✓ Evaluated different filtration strategies

- ✓ Participants completed questionnaires

FRESSCA MUJERES AIRE LIMPIO EN CASA

- ✓ Conducted in 2023
- ✓ Enrolled ~50 female agricultural workers from Kern, Kings, and Fresno Counties



- ✓ Installed portable air cleaners in all homes
- ✓ Installed filters on swamp coolers in half of homes
- ✓ Measured air pollutant levels inside and outside of the homes

- ✓ Collected participants' urine to measure chemicals that show exposure to air pollution

- ✓ Participants completed questionnaires

Field Installation Study Design (Pilot vs Full Intervention)

Metric	Pilot (2022)	Full Intervention (2023)
Homes recruited	• 31	• 58
Homes completed	• 25	• 48
Counties	• Fresno • Kern	• Fresno • Kern • Kings
Intervention duration	• Deployment: July – September • Retrieval: October	• Deployment: July – October • Retrieval: October
Intervention types	• 9 homes: DIY EC filter only • 9 homes: PAC (HEPA) only • 6 homes: DIY Box fan + MERV13 filter • 1 home: no intervention • 4 of 25 effectively control due to non-use/failure	• All homes: PACs with HEPA (Levoit 300, Winix D360, Levoit H133) • 23 homes: Single Intervention (SI), where each home has only a PAC • 25 homes: Double Intervention (DI) where each home has a DIY EC filter with a PAC
Monitors	• Each home has one PA-II monitor (Wi-Fi-only) with outdoor monitors • Limited number of Onset HOBO Plug Load Data Loggers	• Each home has one PA-II monitor (Wi-Fi-only + SD card) with outdoor monitors • Onset HOBO Plug Load Data Loggers for ECs and PACs

FRESSCA Field Surveys

- The team visually surveyed homes to document the types, sizes, and conditions of ECs
- ~85% of homes had a through-the-wall or through-the-window (horizontal-flow) EC unit others were served by a rooftop (downflow) EC unit
  - ECs from at least seven different manufacturers
  - EC dimensions varied from ~36 ×36 ×30-inches, with air intake sizes ~19 ×19-inches to ~40 ×35 ×35-inches, with air intake sizes of ~30 ×35-inches
- The focus was on devising a filtration solution primarily for the horizontal-flow units

Laboratory Testing

- Three common ECs were acquired (two centrifugal fans, one axial)
- Each unit was mounted on a custom wood frame
- Tested during both wet and dry pad conditions

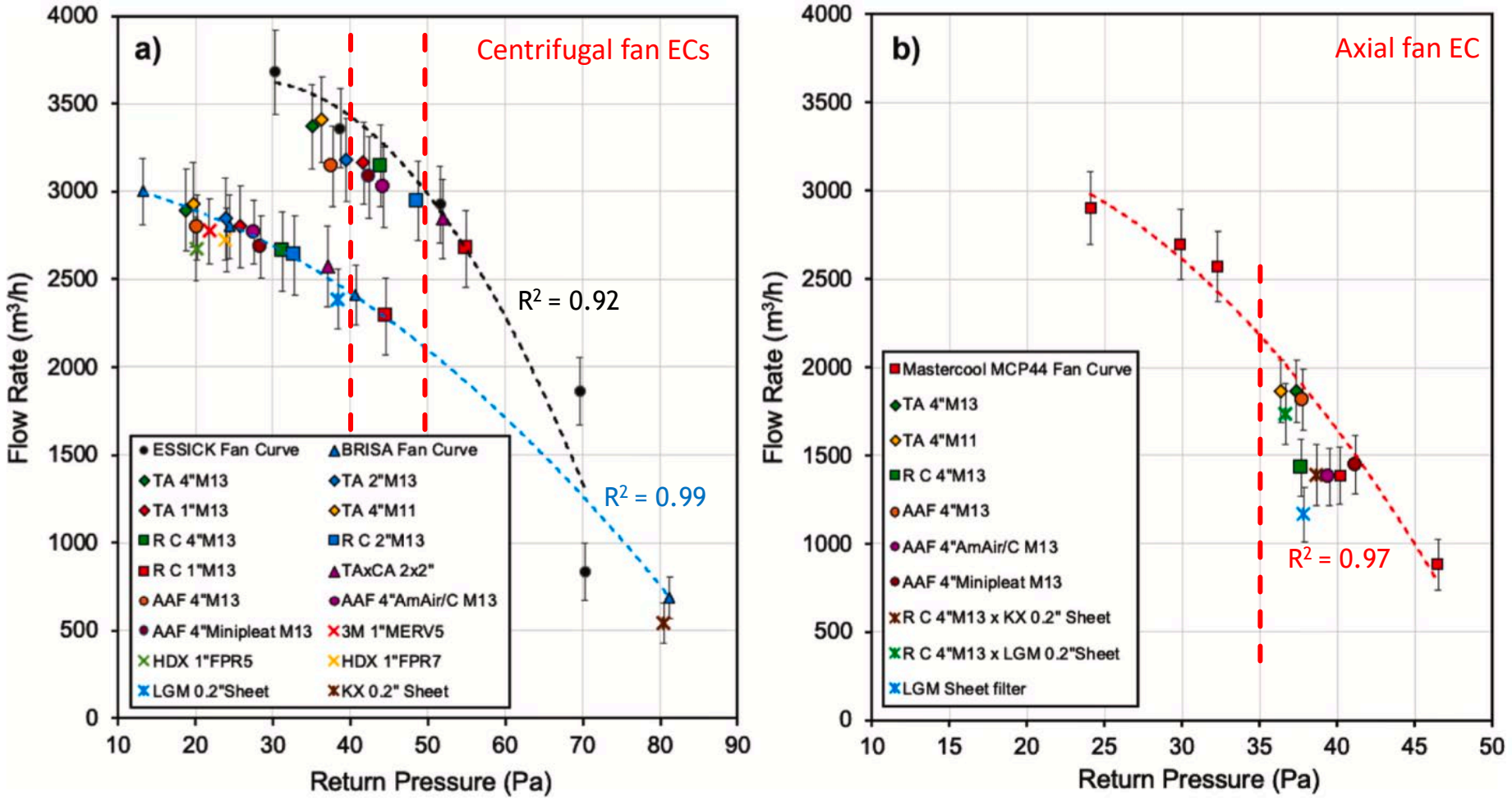
Overarching Design Goals:

- Filter media that could remove pollutants in wildfire smoke with acceptable efficiency, while not excessively restricting airflow
- The solution should be able to:
  - Be installed without specialized training
  - Comprising readily accessible components
  - Be cost-effective to consumers
  - Last the duration of a typical wildfire smoke event in the field (i.e., up to about a month)

(a) tie-down ratchet straps, (b) bungee cords, (c) bungee straps, and (d) custom plenum-like intake and housing for filters

Laboratory Testing

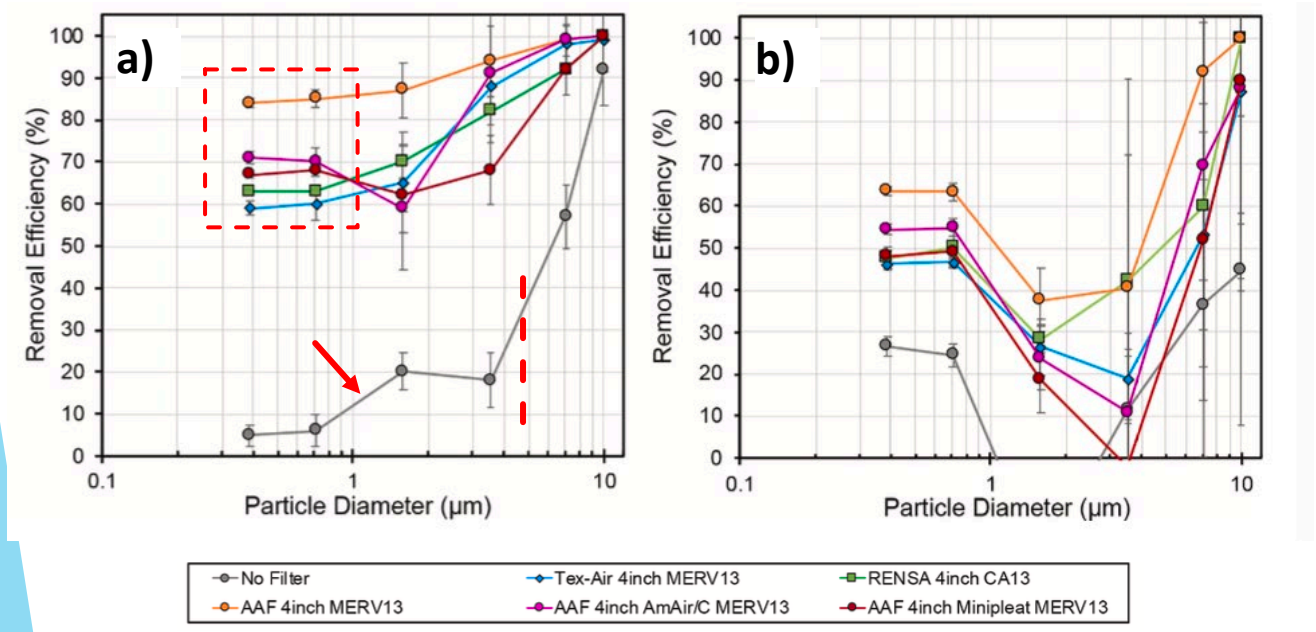
- Airflow rates with different filters were tested



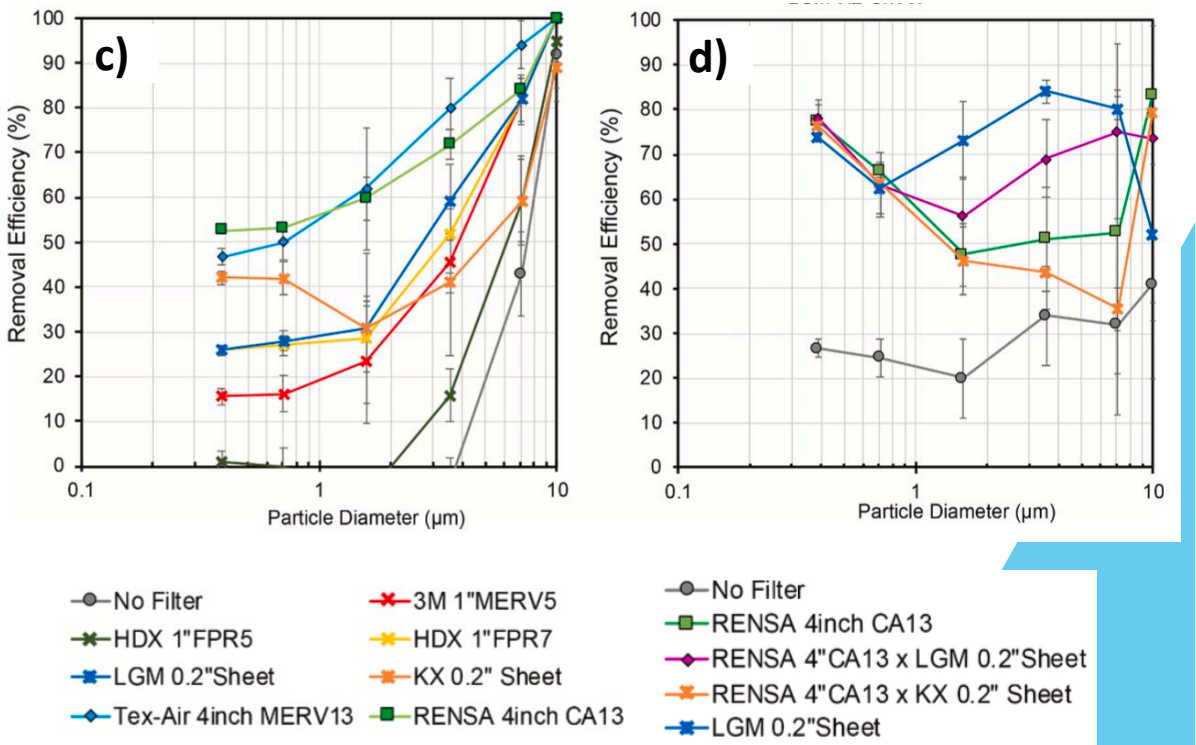
Laboratory Testing

- Particle removal efficiency of different filters were tested

Test of Lab Filters



Test of Locally Available Filters



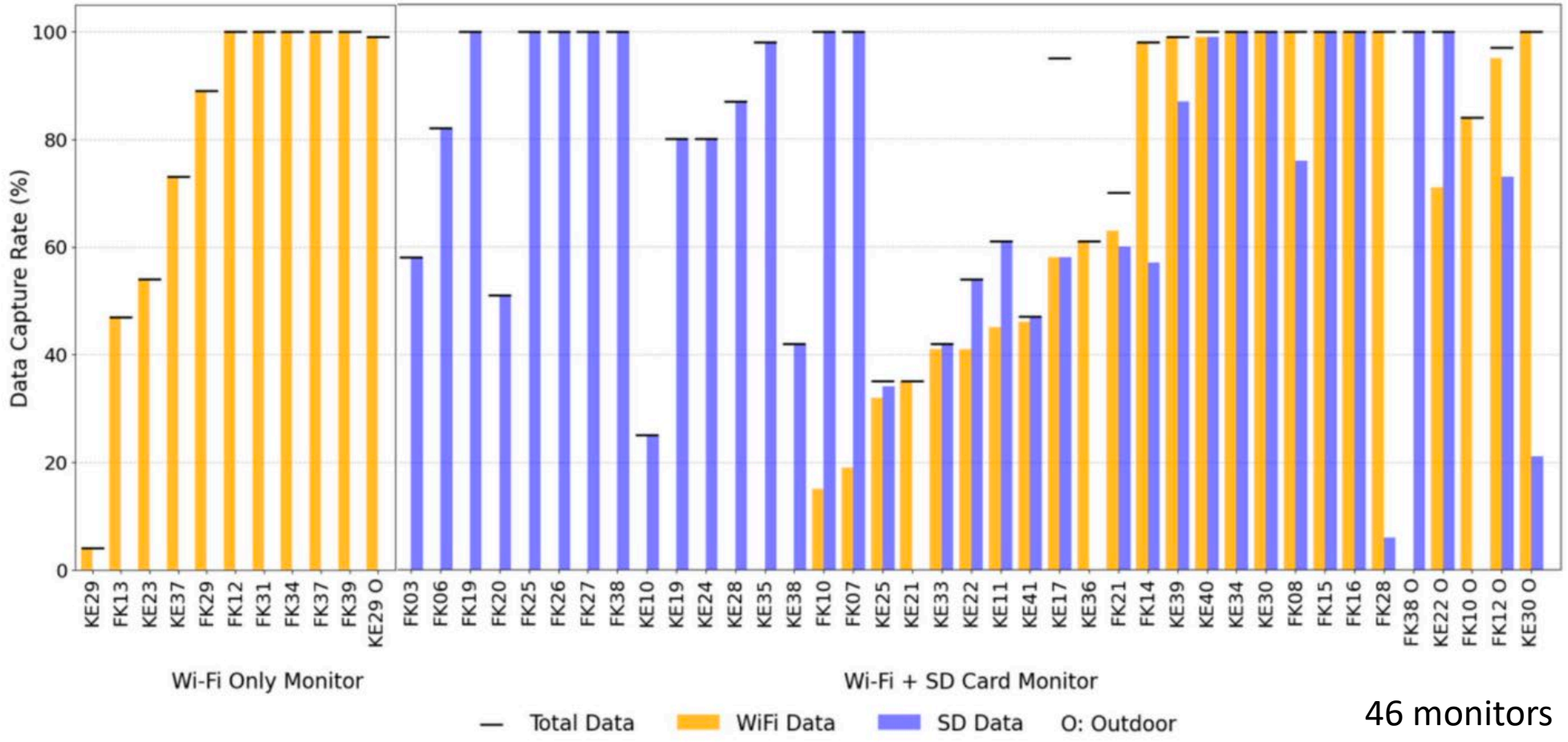
Indoor and Outdoor Air Quality Monitoring

- Installed PA-II inside each home and at eight nearby outdoor locations

- Co-located PA-II monitors for calibration:

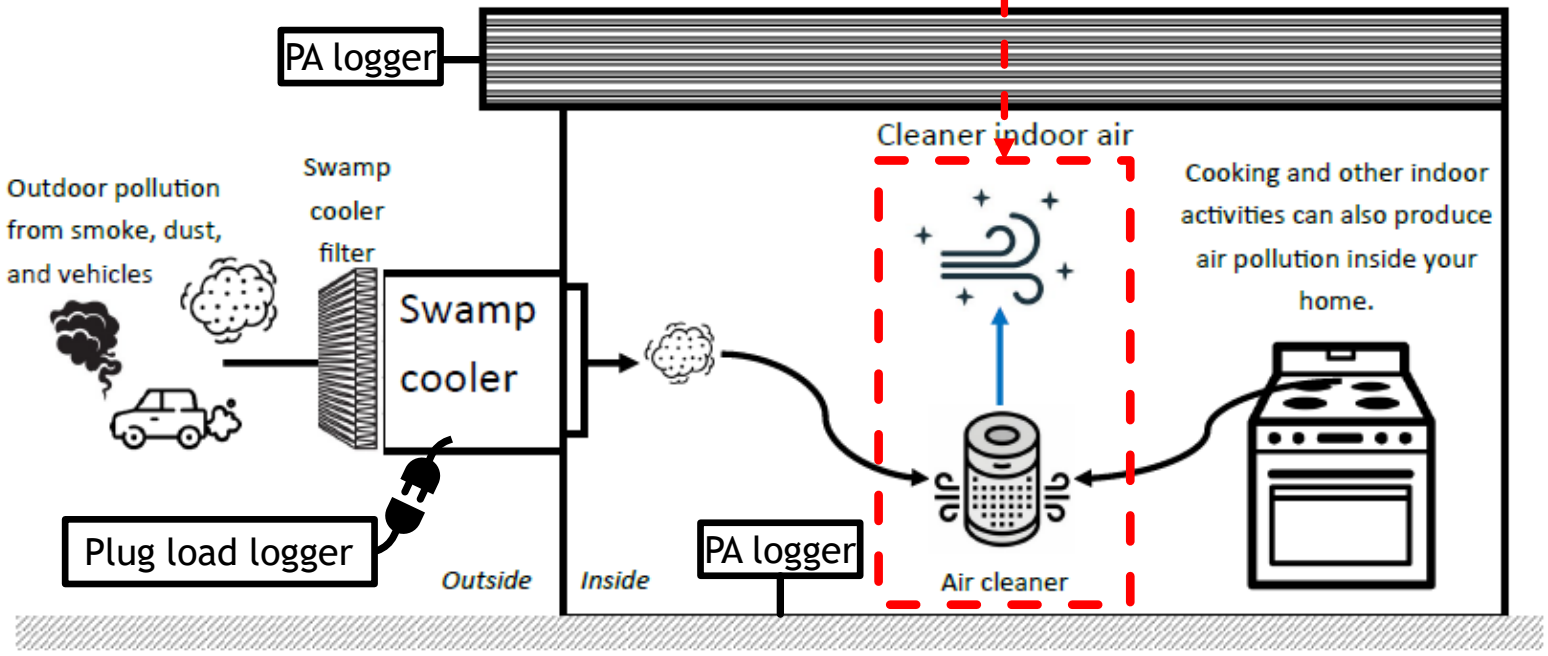
Indoor and Outdoor Air Quality Monitoring

- Wi-Fi data capture rate in the field was only 56%
  - Increased to 82% when integrated with data collected from the onboard microSD cards



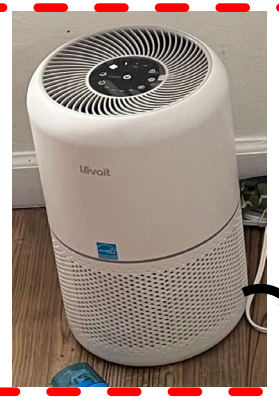
46 monitors

Field Interventions



Double Interventions (DI)

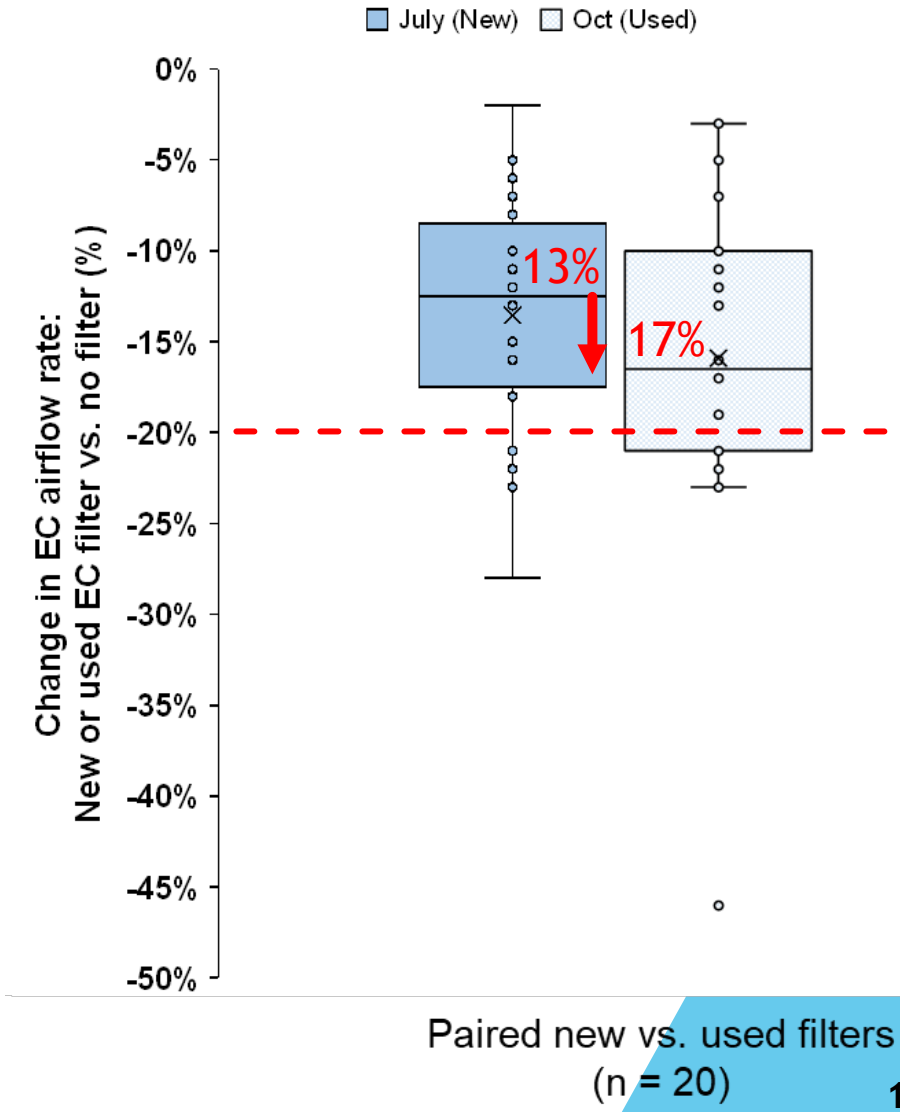
Single Intervention (SI)



Plug load logger

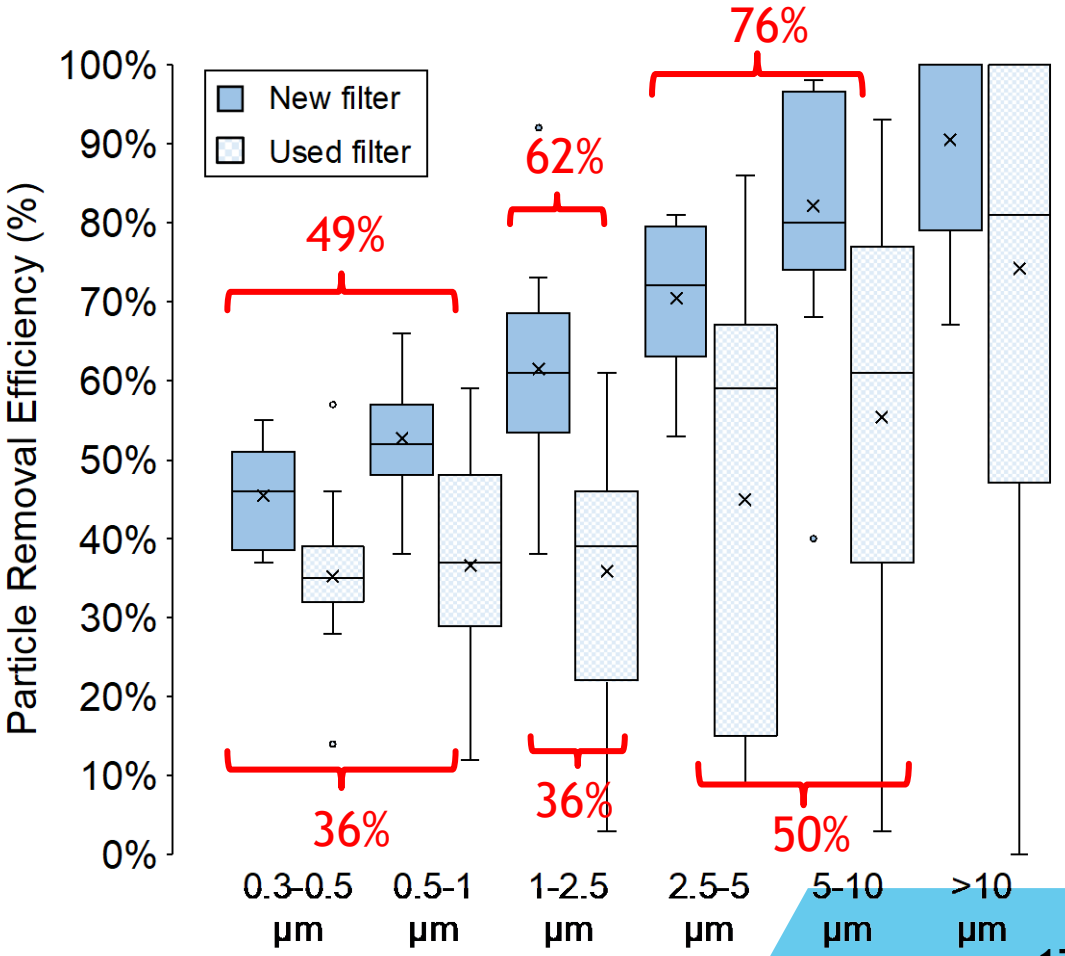
Full Scale Intervention (Spot Measurements)

- The median (IQR) reduction in flow rate with the filter installed compared to that without a filter was 15% (11-23%) (Consistent with the laboratory testing)
- ~70% of homes met the design goals of new EC filters (<20% flow reduction)
- Particle loading on the filters over time impacted the pressure drop, and a modest reduction in airflow



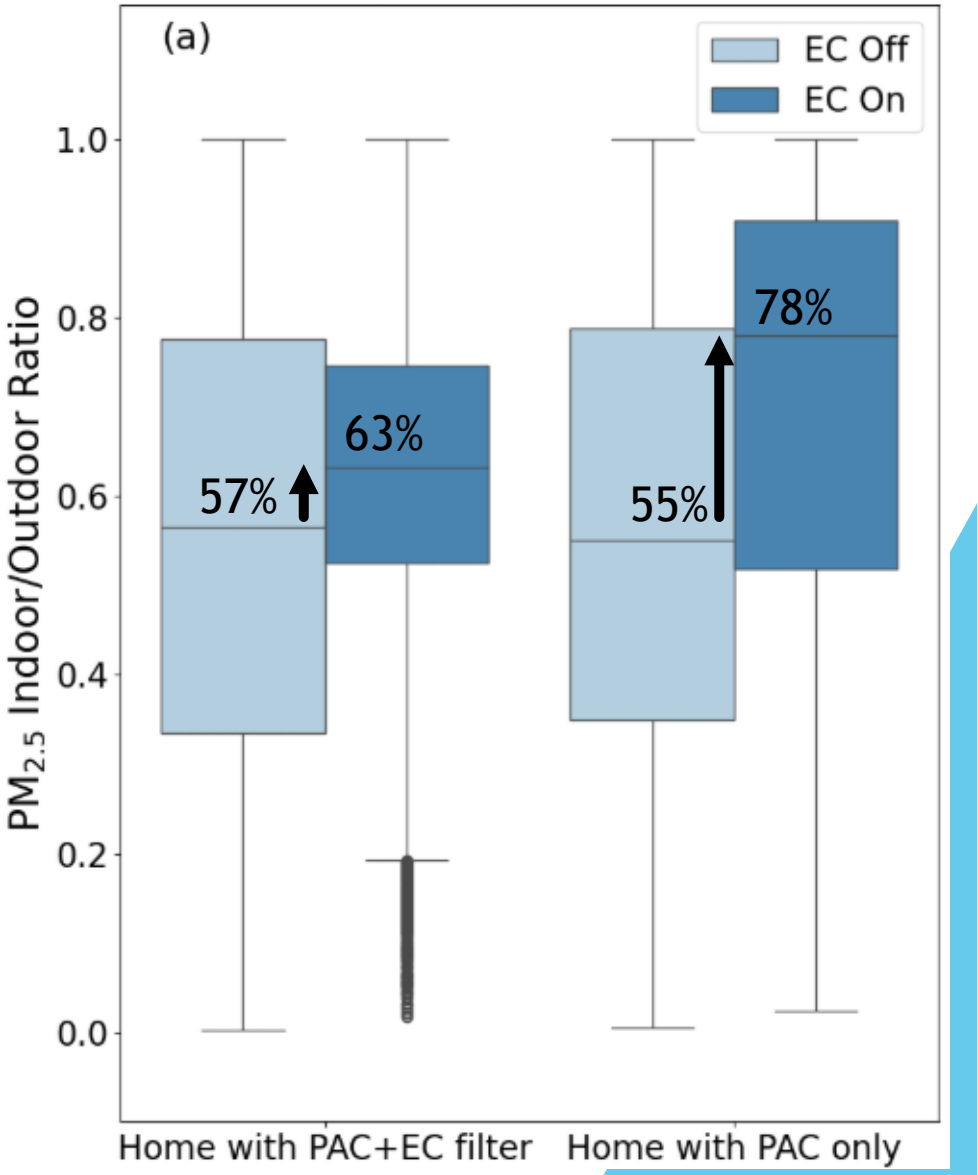
Full Scale Intervention (Spot Measurements)

- Practical removal efficiency measurements were conducted in 10 paired homes
- Size-resolved efficiency curves approximately followed expectations for MERV 13 filters
- The mean removal efficiency for particles decreased over time
- The reduction was likely caused by reduced electrostatic charge, water damage, and bypass airflow around filters



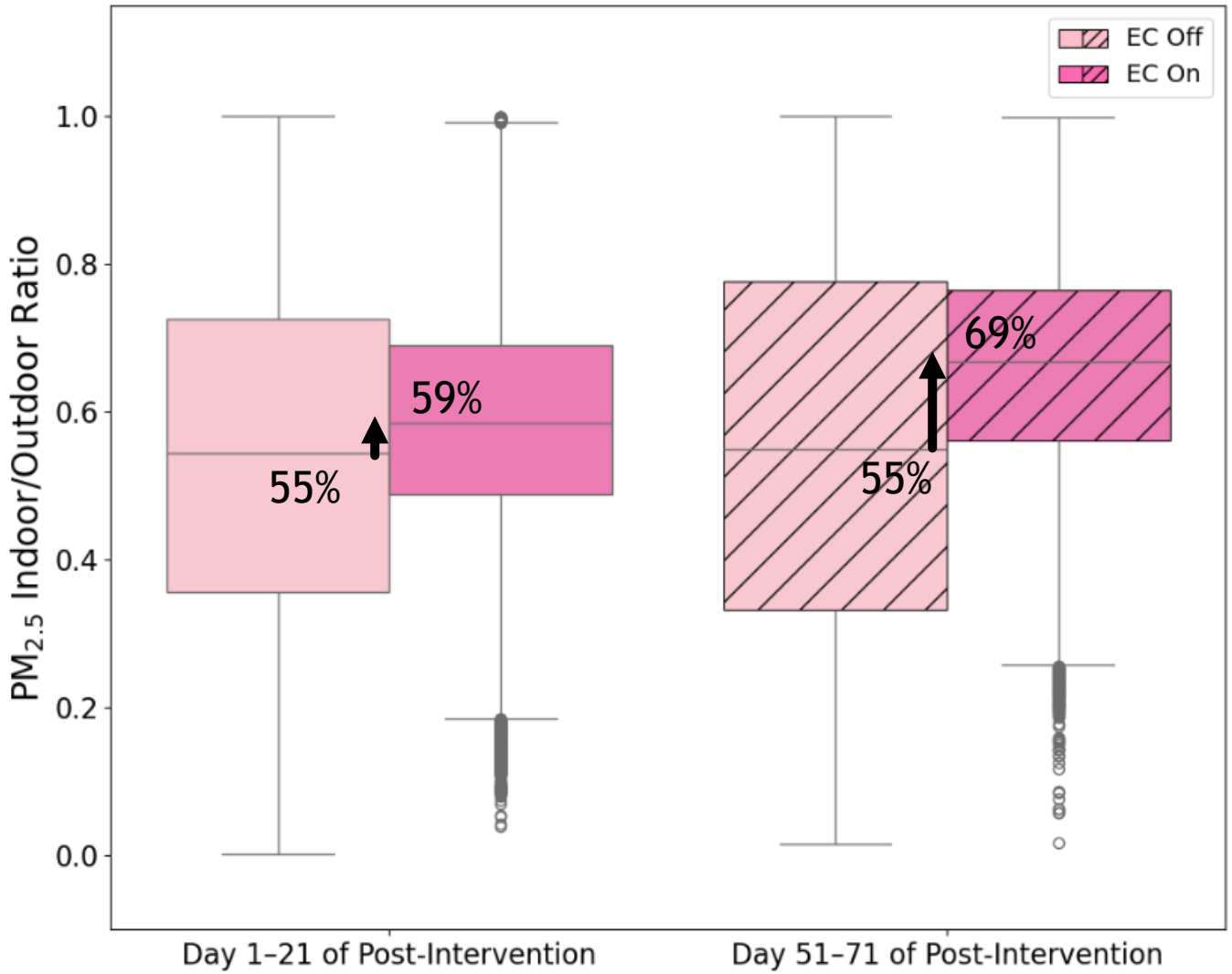
Did the air quality interventions improve indoor air quality?

- DI homes were compared with the SI homes in periods during which ECs were either known to be operating or predicted to be operating
- In SI homes, indoor $PM_{2.5}$ of predominantly ambient origin increased
- In DI homes, EC filters mitigated the additional infiltration of ambient $PM_{2.5}$, and indoors remained similar to that observed during EC off



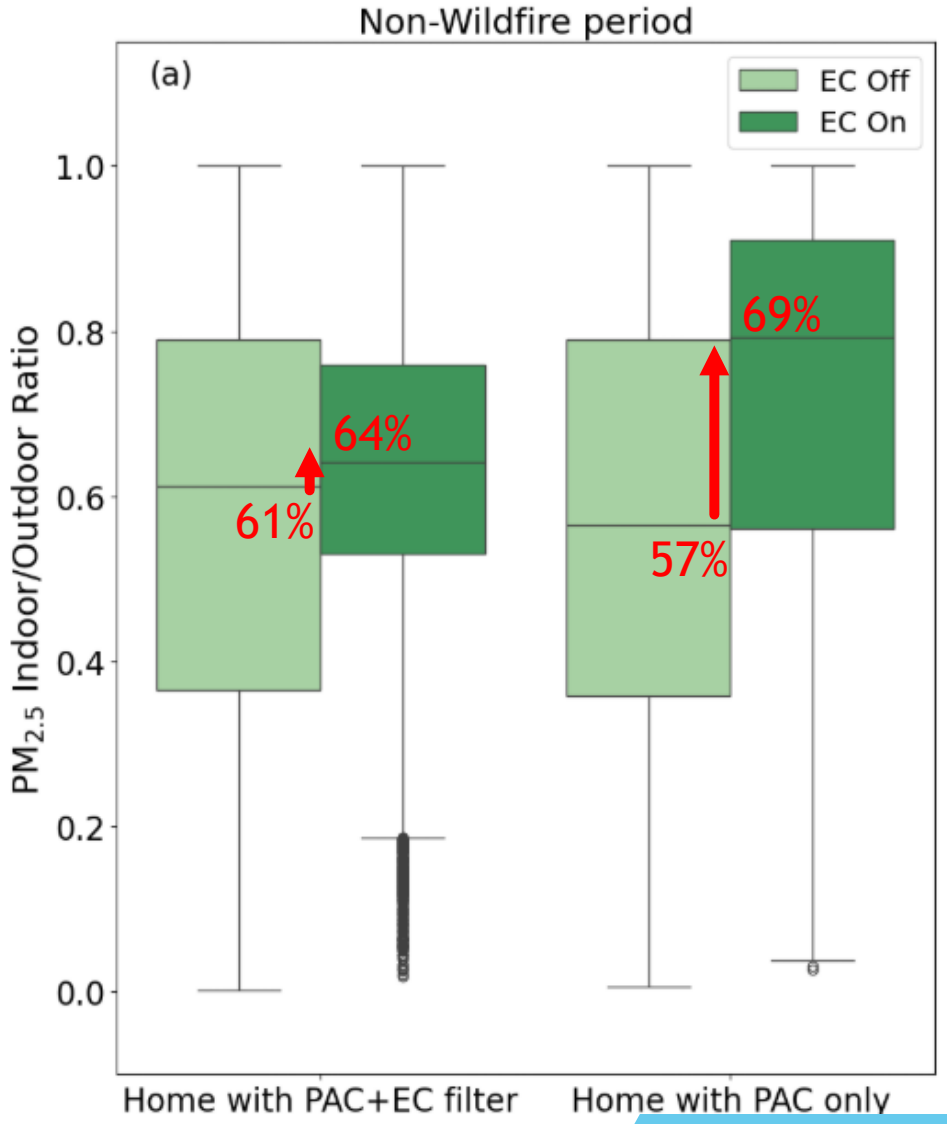
Impacts of new vs. used filters on $PM_{2.5}$ infiltration

- The I/O was compared when ECs were known or predicted to be off, compared to when ECs were known or predicted to be operating
- The median constrained I/O $PM_{2.5}$ ratio increased by:
  - +7% for Day 1-21 of post-installation ($p < 0.05$)
  - +25% for Day 51-71 of post-installation ($p < 0.05$)



Impacts of filters on $PM_{2.5}$ infiltration during wild-fire periods

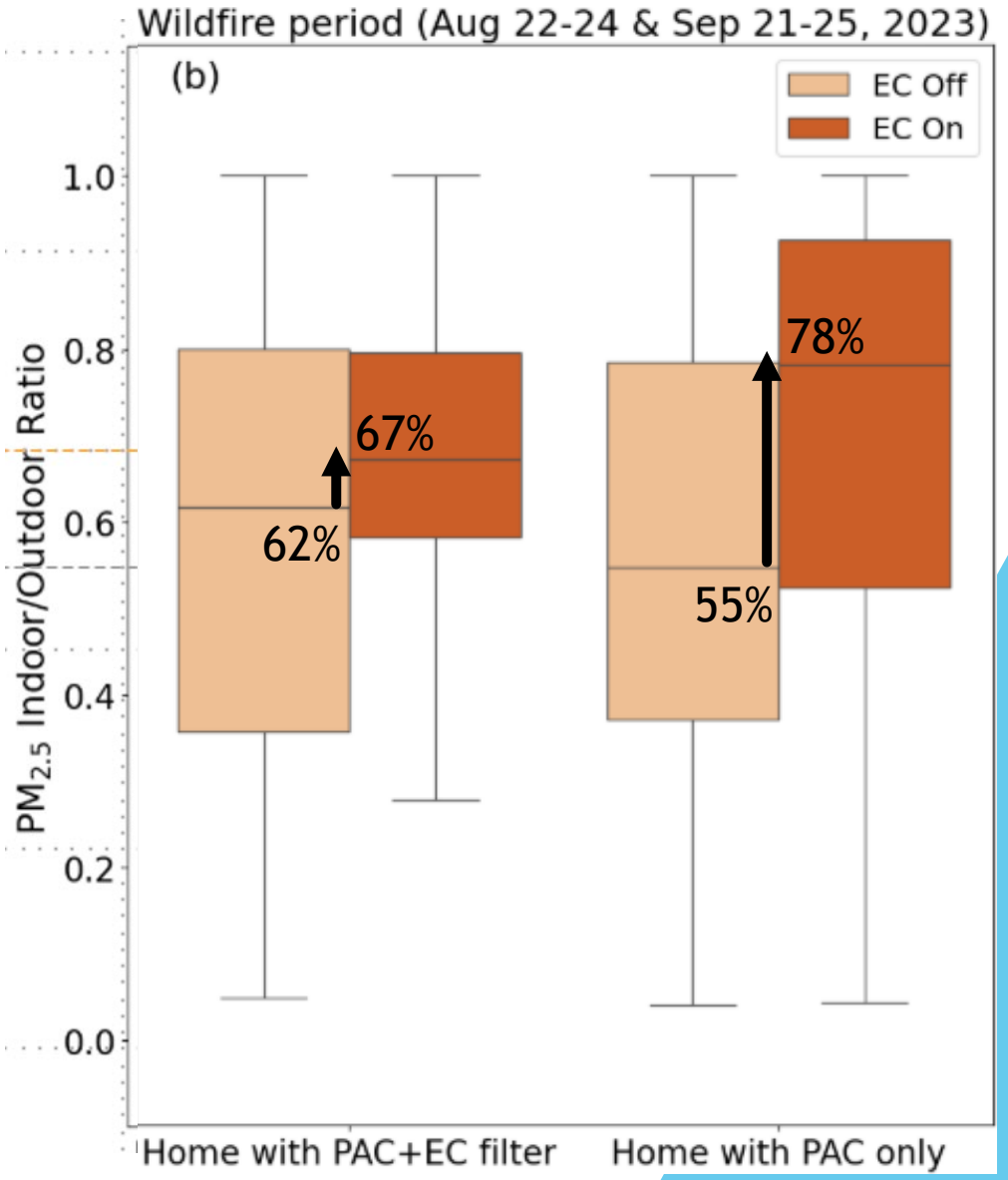
- During non-wildfire periods, the median constrained I/O PM2.5 ratio in homes:
  - In DI homes was 0.61 when ECs were known or predicted to be off, compared to 0.64 when on (+5%)
  - In SI homes was 0.57 when ECs were known or predicted to be off compared to 0.79 (+39%) when ECs on



Impacts of filters on $PM_{2.5}$ infiltration during wild-fire periods

- During wildfire periods, the median constrained I/O PM2.5 ratio in homes:
  - In DI homes was 0.62 when ECs were known or predicted to be off, compared to 0.67 when on (+8%)
  - In SI homes was 0.55 when ECs were known or predicted to be off compared to 0.78 (+42%) when ECs on

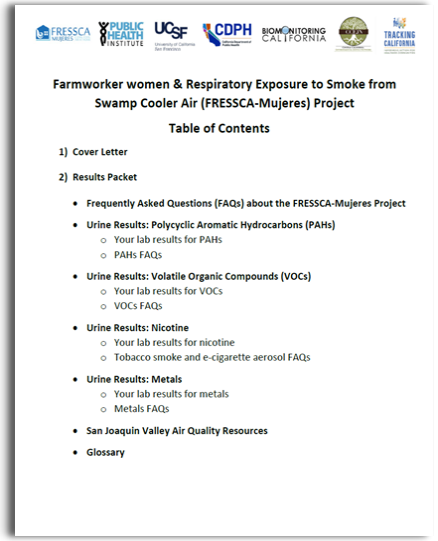
While the wildfire in 2023 was not as severe as in previous years, the solution worked!



Summary of the Swamp Cooler Filtration Interventions:

- Both the pilot and intervention years showed that the swamp cooler filtration solution works for the short-term wildfire installation, impacting airflow with minimal training
- The DIY solution requires no prior training and relies on accessible, off-the-shelf, commercially available components
- Double intervention, the use of both filters (MERV 13) and portable air cleaners, maximizes the filtration efficiency and improves indoor air quality by lowering levels of $PM_{2.5}$ and PM_{10}
- The performance of swamp cooler filters decreases over time
- Overall, it is recommended to install the swamp cooler filters before the wildfire, not earlier than that

What else was measured in FRESSCA-Mujeres?



Farmworker women & Respiratory Exposure to Smoke from Swamp Cooler Air (FRESSCA-Mujeres) Project

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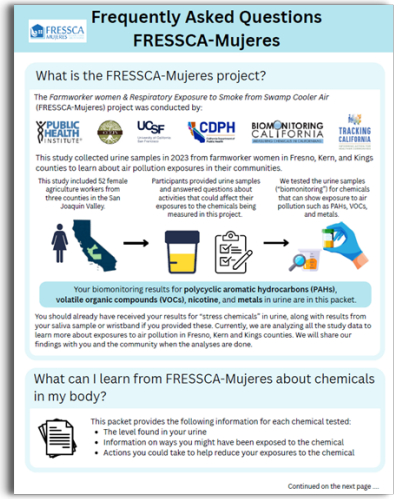


Frequently Asked Questions
FRESSCA-Mujeres

What is the FRESSCA-Mujeres project?

The *Farmworker women & Respiratory Exposure to Smoke from Swamp Cooler Air* (FRESSCA-Mujeres) project was conducted by:

This study collected urine samples in 2023 from farmworker women in Fresno, Kern, and Kings counties to learn about air pollution exposures in their communities.

This study included 52 female agriculture workers from three counties in the San Joaquin Valley.

Participants provided urine samples and answered questions about activities that could affect their exposures to the chemicals being measured in this project.

We tested the urine samples ("biomonitoring") for chemicals that can show exposure to air pollution such as PAHs, VOCs, and metals.

Your biomonitoring results for **polycyclic aromatic hydrocarbons (PAHs)**, **volatile organic compounds (VOCs)**, **nicotine**, and **metals** in urine are in this packet.

You should already have received your results for "stress chemicals" in urine, along with results from your saliva sample or wristband if you provided these. Currently, we are analyzing all the study data to learn more about exposures to air pollution in Fresno, Kern and Kings counties. We will share our findings with you and the community when the analyses are done.

What can I learn from FRESSCA-Mujeres about chemicals in my body?

This packet provides the following information for each chemical tested:
- The level found in your urine
- Information on ways you might have been exposed to the chemical
- Actions you could take to help reduce your exposures to the chemical

Continued on the next page ....

- Polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and metals were measured in:
  - Indoor and outdoor air (presented at Nov 2024 SGP meeting)
  - Urine samples
- Biomarkers of stress in urine
- For a subset of participants:
  - Saliva telomere length
  - Silicone wristbands

Demographics (N = 51)

- All Hispanic/Latina women
- Primarily Spanish speakers
- Non-smoking

		Mean (Range) or N (%)
Age of Participants		41 (22- 61)
Rent or Own Home	Rent	11 (22%)
	Own	39 (76%)
	Not reported	2 (2%)
Health insurance	Medi-Cal or Medicare	36 (71%)
	Private health insurance	4 (8%)
	Uninsured	11 (21%)
Occupation	Farm workers	35 (68%)
	Food packaging and processing	8 (16%)
	Other	8 (16%)

FRESSCA-Mujeres Study Timeline

Biomonitoring (PAHs, VOCs, metals)

Spring/Summer Biomonitoring Samples

First morning void

Fall Biomonitoring Samples

Evening

First morning void

Intervention Installation

PACs: All participants

Swamp coolers filters: Half of the participants

2023 Apr May Jun Jul Aug Sep Oct Nov Dec

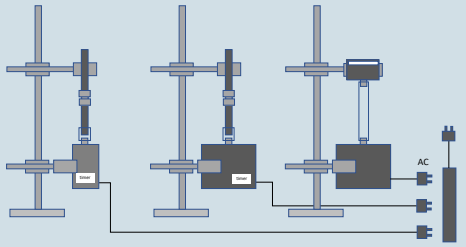
Air Monitoring

Continuous $PM_{2.5}$ sensors

Passive PM samplers (Subset of samples)

Active air samplers

VOCs PAHs Metals



Data analysis

- Non-detects were imputed with reporting limit $/\sqrt{2}$
  - Analysis was not conducted if detection frequency (DF) was <65%
- Specific gravity adjusted and log transformed values for statistical analysis
- Average log transformed creatinine adjusted values for comparisons with NHANES
- Number of urine samples used in analysis varied depending on each time period
- Approximate participant locations were used for geospatial analyses

Detection frequencies in urine samples (N=137)*

VOC	Metabolite	Detection %
Acrolein	3-HPMA	100%
Acrylonitrile	CNEMA	65%
Benzene	PMA	7%
1,3-Butadiene	MHBMA12	1%
	MHBMA3	7%
Crotonaldehyde	HPMMA	100%
Propylene oxide	2-HPMA	100%

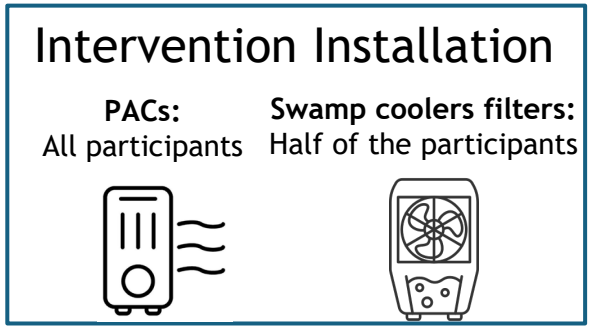
Metal	Detection %
Antimony	93%
Arsenic	100%
Cadmium	100%
Manganese	28%
Mercury	92%
Nickel	99%

PAH	Metabolite	Detection %
Fluorene	2-FLUO	97%
	3-FLUO	73%
	9-FLUO	97%
Naphthalene	1-NAP	100%
	2-NAP	100%
Phenanthrene	1-PHEN	99%
	2-PHEN	92%
	3-PHEN	93%
Pyrene	1-PYR	85%

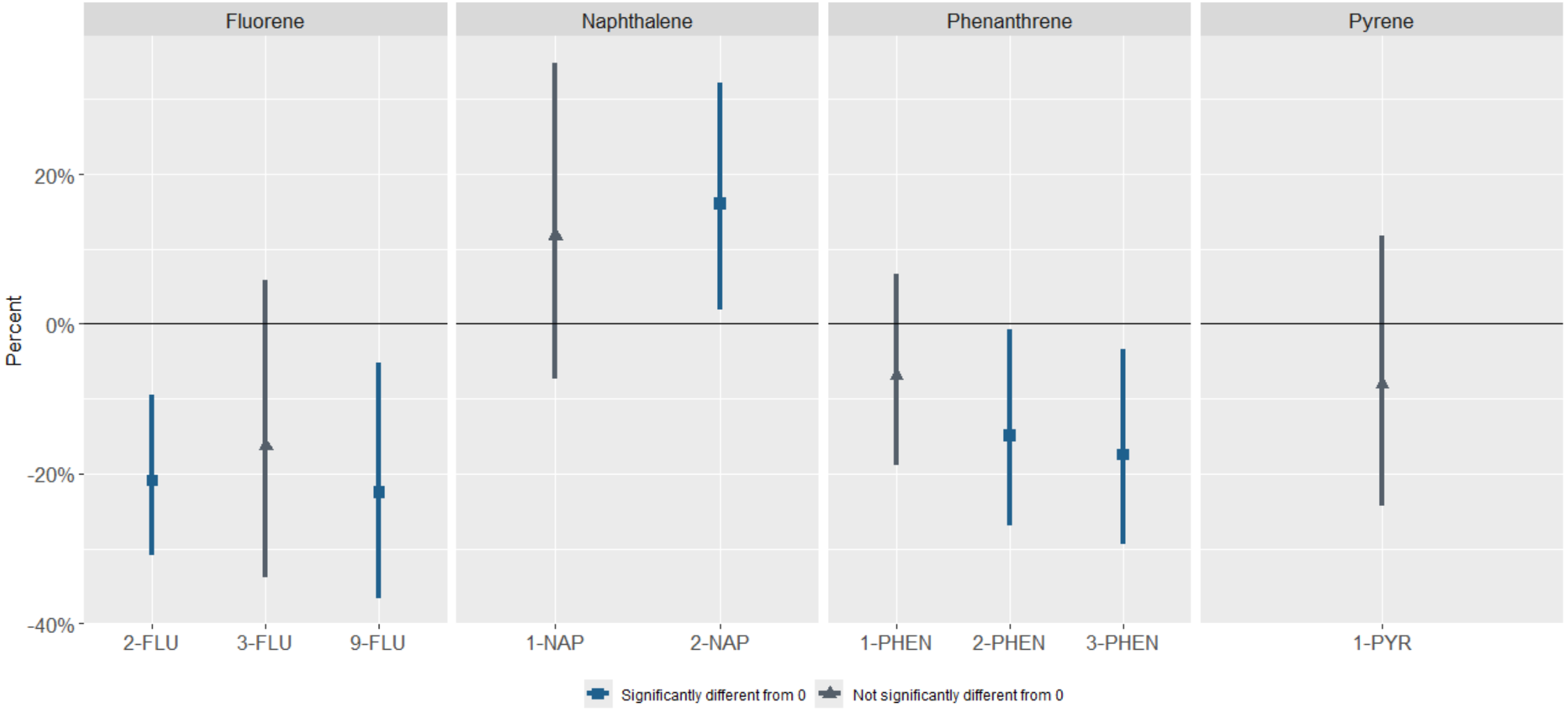
* Includes all samples from all 3 time periods

Did levels of PAH and VOC metabolites in urine decrease after spending time in filtered air?

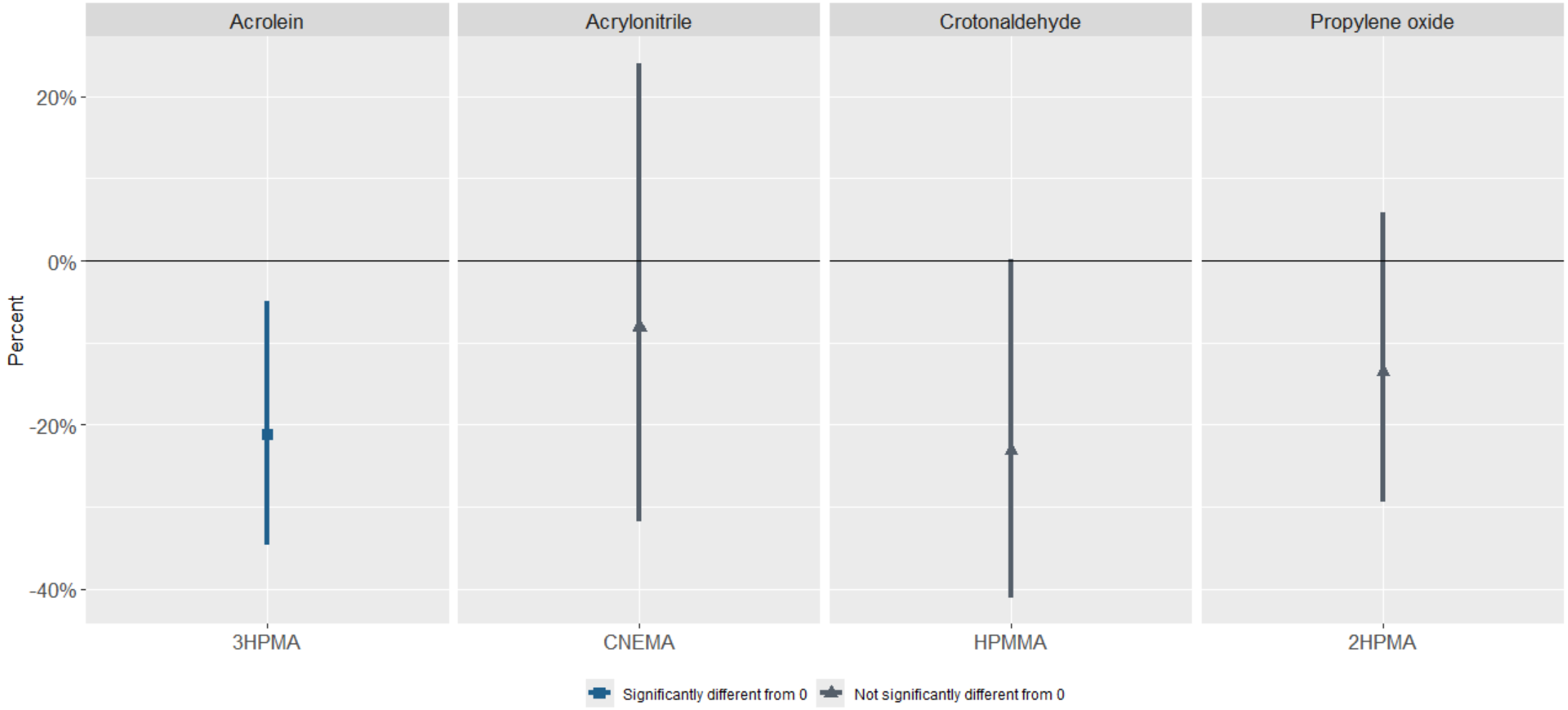
Did the intervention type make a difference?



Percent change in PAH metabolite concentrations overnight



Percent change in VOC metabolite concentrations overnight



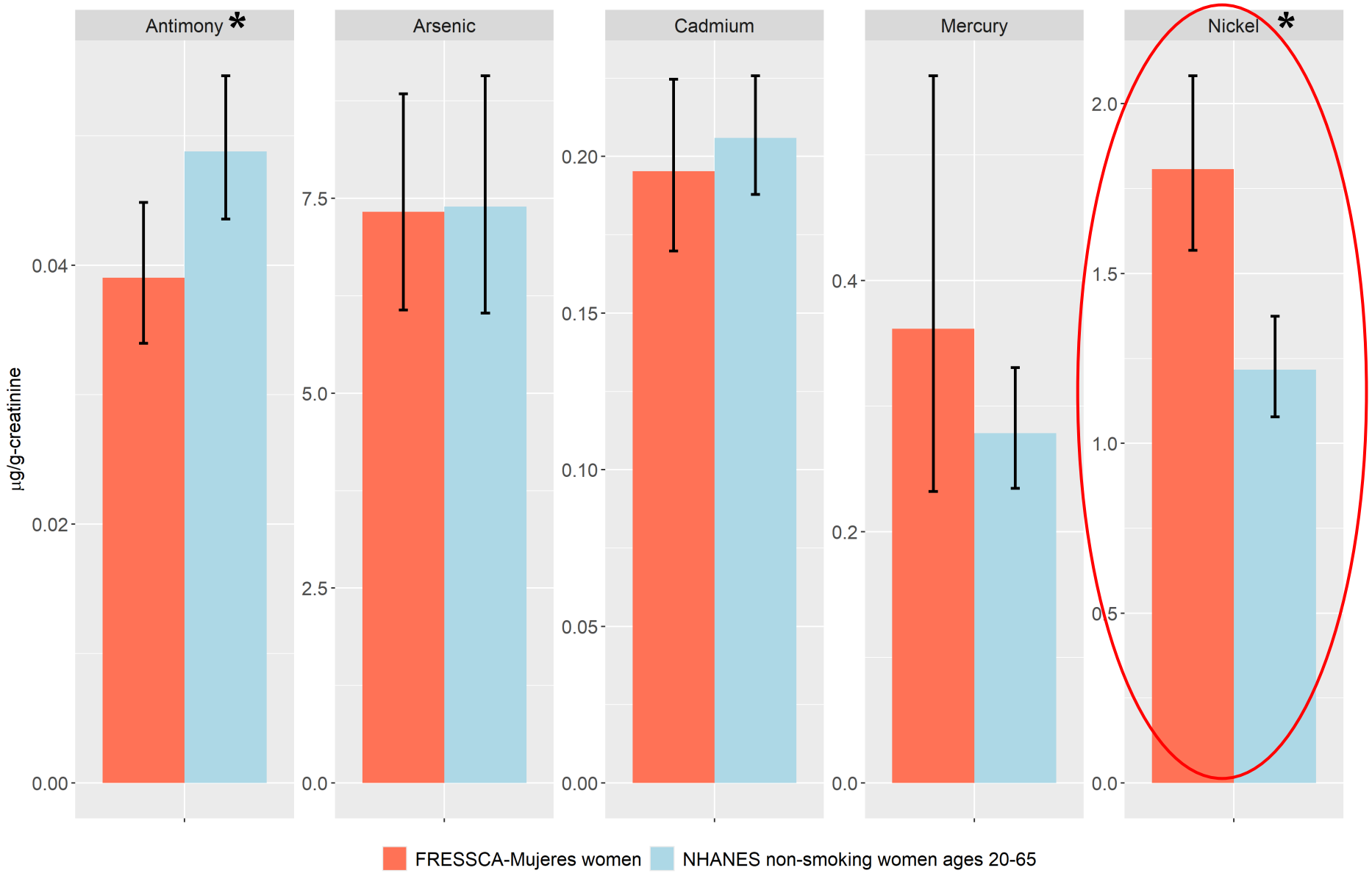
Summary of intervention findings

- Metabolites of PAHs and VOCs generally decreased after spending time indoors, except for naphthalene
  - Might partially be explained by air filtration
- No significant differences between spring/summer and fall metabolite levels
  - No major wildfire event
- Did not see a significant difference in metabolite levels based on intervention type
  - Similar finding for PAHs and VOCs in air
  - No major wildfire event
  - Small Ns
  - Majority of participants did not have their swamp coolers on at night

How do the levels of metals and PAH and VOC metabolites in FRESSCA-Mujeres compare to NHANES?

Metals in urine

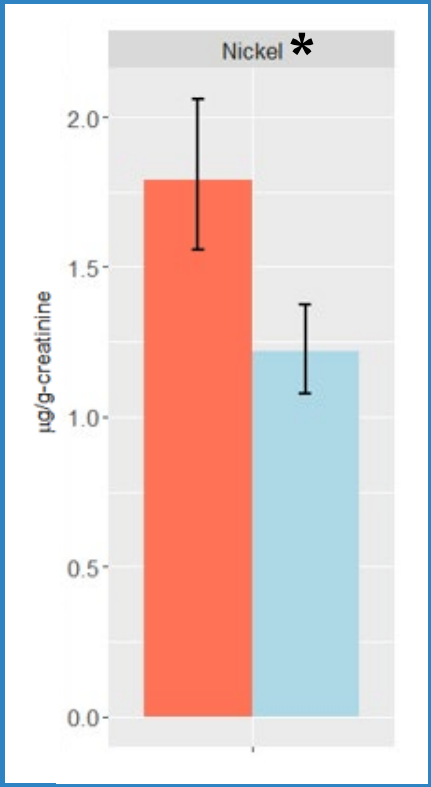
Geometric means of urinary metals from FRESSCA-Mujeres and NHANES



Source for urinary metals: NHANES 2017-2018

* $p<0.05$

Nickel in urine



Nickel was 1.5x higher in FRESSCA compared to NHANES

- No associations with questionnaire data
  - Did not see any differences based on occupation
- Nickel was below level of detection (<LOD) in FRESSCA 24 hr active air samples
  - Nickel was detected in passive air samples and EC filters
    - Consistently higher in outdoor passive air samples compared to indoor samples
    - Potential exposures to emissions from nearby oil and gas activities
- Nickel was <LOD in drinking water (based on data from the CA Water Board)

Urinary mercury above Biomonitoring California's Level of Concern (LOC)

5 participants had mercury ≥ 10 µg/L

Received early notification

3 participants participated in exposure survey

Skin creams from 3 participants were tested by CDPH

Mercury was detected in all samples

Home assessments for 2 participants were completed

Urinary arsenic above Biomonitoring California's LOC

3 participants had total arsenic ≥ 50 µg/L

Received early notification

2 participants had inorganic arsenic ≥ 20 µg/L

1 participant participated in exposure survey

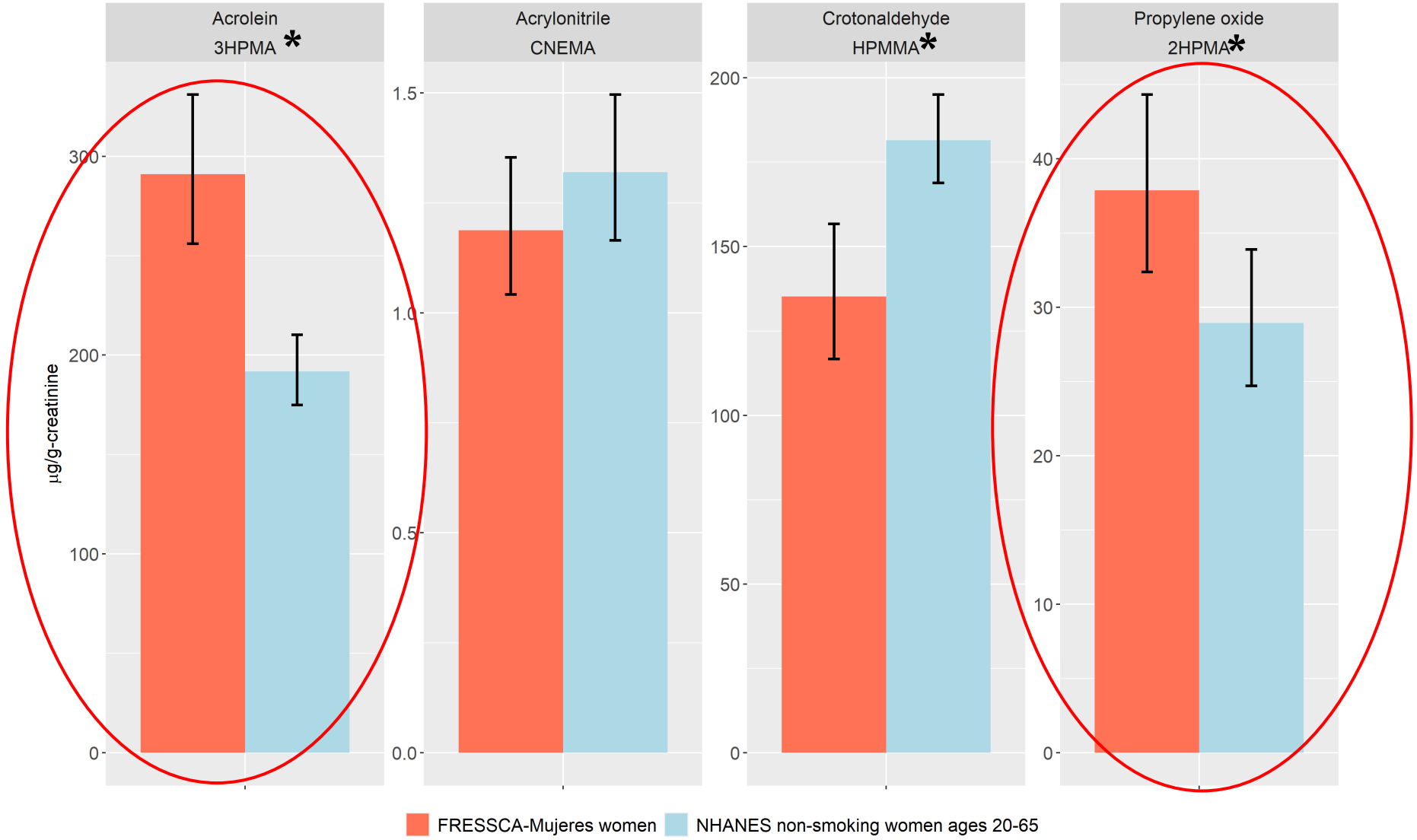
Likely *not* due to drinking water system

1 participant had high levels of organic arsenic

Likely due to seafood consumption

VOC metabolites in urine

Geometric means of urinary VOC metabolites from FRESSCA-Mujeres and NHANES



Source for VOC metabolites NHANES 2017-2018

* $p<0.05$

Acrolein and propylene oxide

Compared to morning samples, post work samples were:

- 27% higher in **acrolein** metabolites
  - Levels were around 17% higher for each additional hour worked outside
- 16% higher in **propylene oxide** metabolites (not significant)

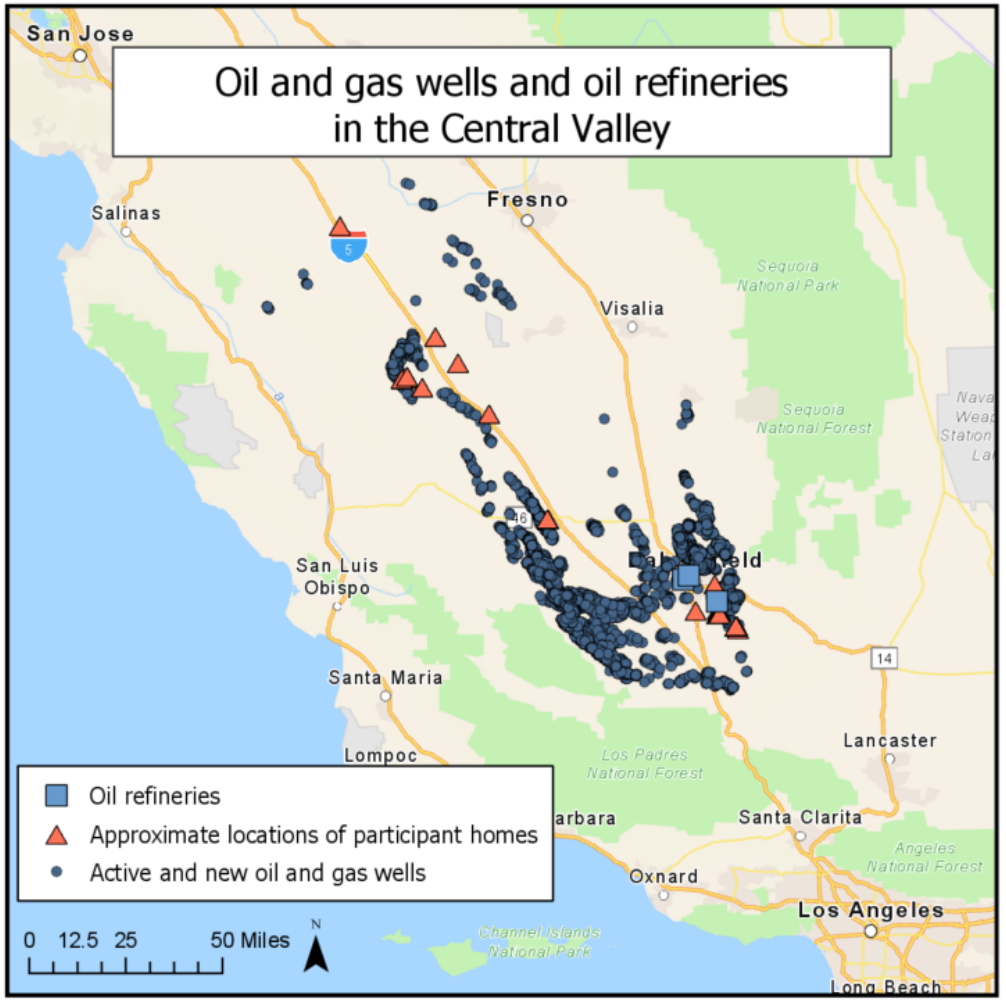
Based on 2023 DPR data, there was evidence of use of:

- Two pesticides containing **acrolein**
- One pesticide containing **propylene oxide**

- Did not have FRESSCA-Mujeres indoor or outdoor air monitoring data for acrolein and propylene oxide

Are oil and gas activities contributing to exposures in FRESSCA-Mujeres?

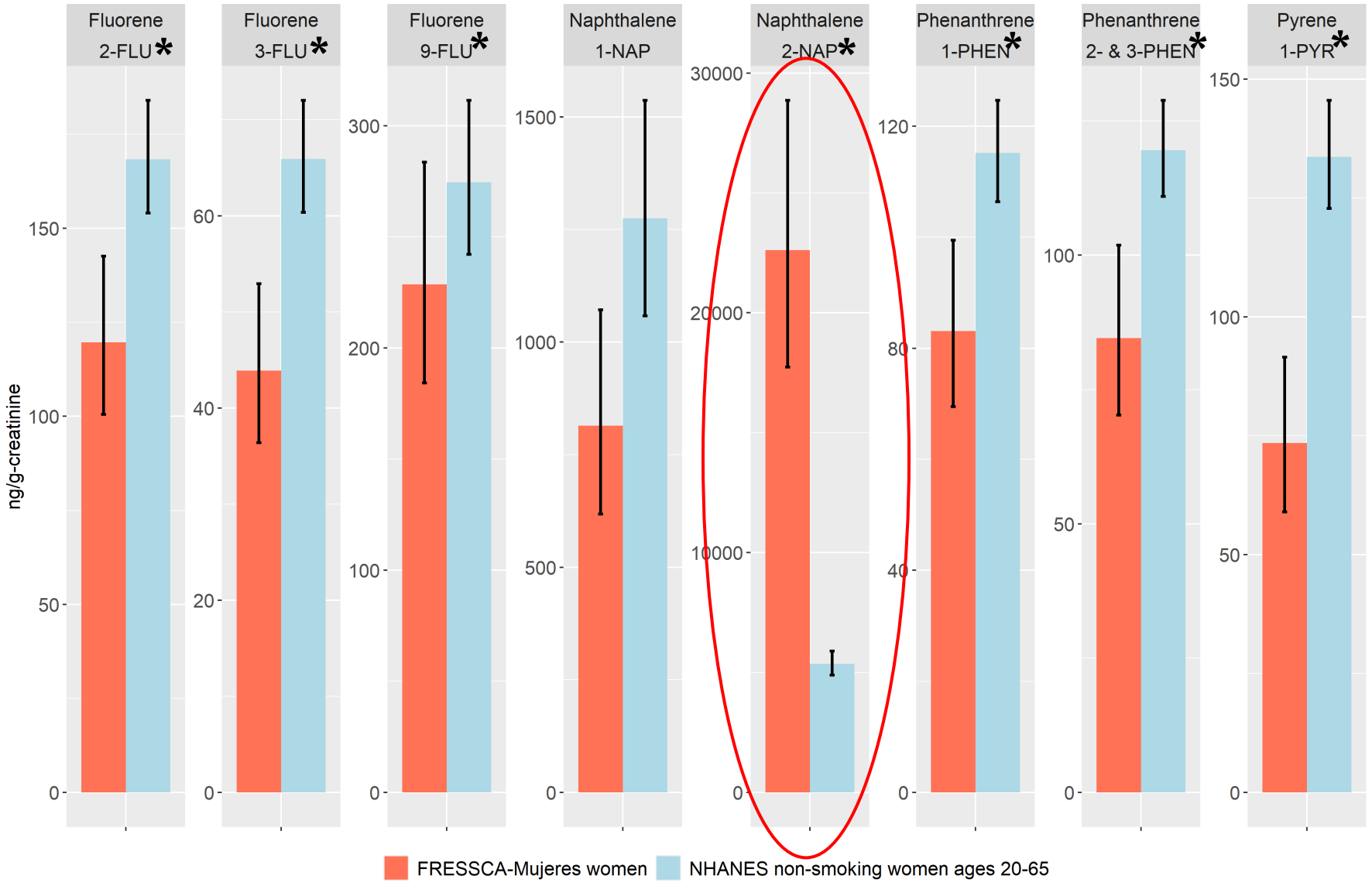
- CARB's Study of Neighborhood Air near Petroleum Sources (SNAPS) report found elevated levels of acrolein in air in Lost Hills compared to other locations in the Central Valley
- Nickel is also often found in air emissions from oil and gas activities
- 6 participants lived within 3200 feet of an active well
- Participants' work locations may be more relevant to exposure period - however, work locations are unknown



Source for well data: CalGEM. Source for refinery data: CA Energy Commission.

PAH metabolites in urine

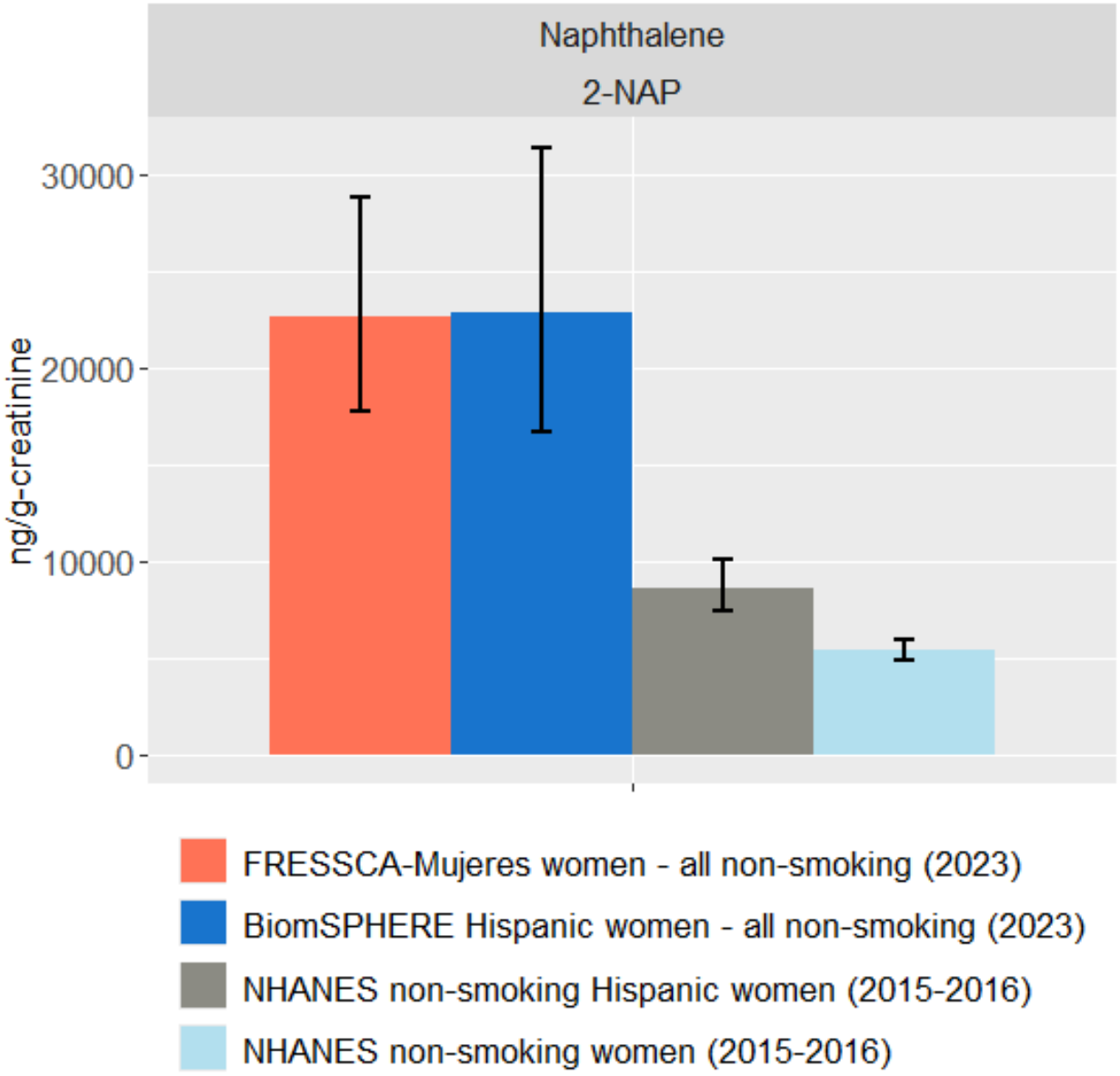
Geometric means of urinary PAH metabolites from FRESSCA-Mujeres and NHANES



Source for 9-FLU: NHANES 2011-2012; Source for remaining PAH metabolites NHANES 2015-2016

* $p<0.05$

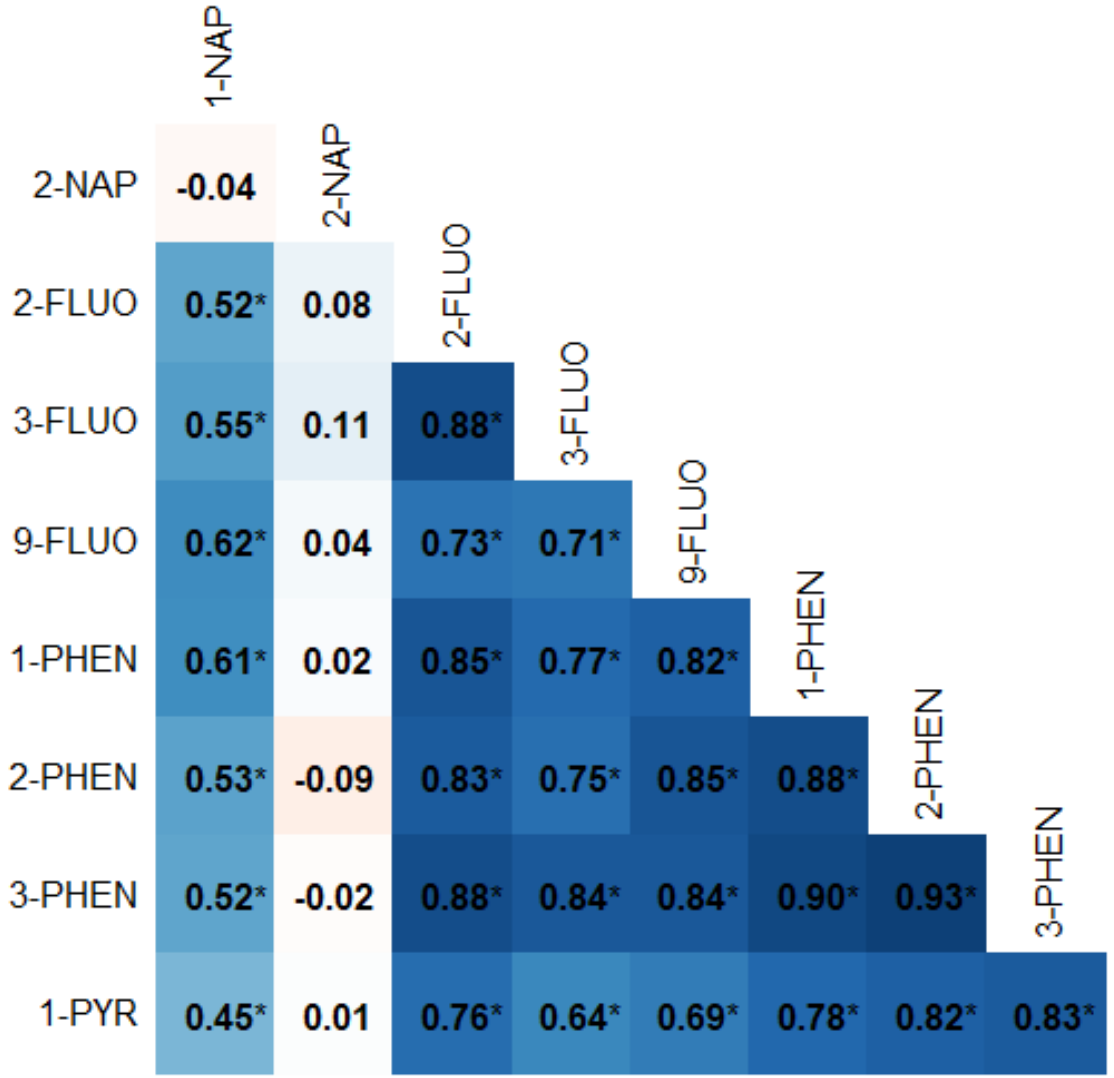
High urinary 2-NAP levels in FRESSCA-Mujeres



- FRESSCA Hispanic women (N=51) had similar levels of 2-NAP compared to Hispanic women from BiomSPHERE (N=43)
- Levels of 2-NAP in FRESSCA and BiomSPHERE Hispanic women were:
  - ~2.5x higher* than Hispanic women in NHANES
  - ~4x higher* than women in NHANES

*p<0.05

2-NAP is not correlated with other PAHs



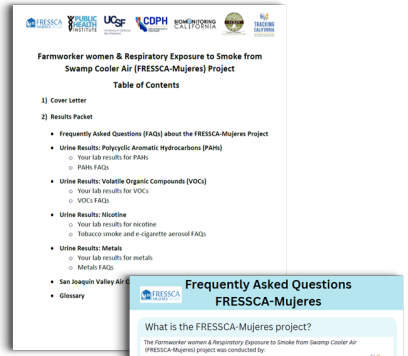
Correlations were calculated using average log-transformed specific-gravity adjusted data *p < 0.05

Summary of 2-NAP findings

- 2-NAP levels were 16% higher* in morning samples vs. evening samples
- No significant associations with cleaning product or air freshener use
- No significant associations with diet (e.g., fried, smoked foods)
- Recent data from other states' biomonitoring programs and published literature indicate a general upward trend of 2-NAP levels
  - However, levels found in SAPEP, BiomSPHERE, and FRESSCA are much higher

*$p<0.05$

Community impacts and perspectives



Farmworker women & Respiratory Exposure to Smoke from Swamp Cooler Air (FRESSCA-Mujeres) Project

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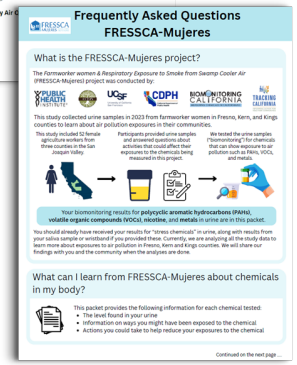

Frequently Asked Questions
FRESSCA-Mujeres

What is the FRESSCA-Mujeres project?

The Farmworker women & Respiratory Exposure to Smoke from Swamp Cooler Air (FRESSCA-Mujeres) project was conducted by:

This study collected urine samples in 2023 from farmworker women in Fresno, Kern, and Kings counties to learn about air pollution exposures in their communities.

This study included 50 female agriculture workers from three counties in the San Joaquin Valley.

Participants provided urine samples and answered questions about activities that could affect their exposures to the chemicals being measured in this project.

We tested the urine samples ("biomonitoring") for chemicals that can show exposure to air pollution such as PAHs, VOCs, and metals.

Your biomonitoring results for **polycyclic aromatic hydrocarbons (PAHs)**, **volatile organic compounds (VOCs)**, **nicotine**, and **metals** in urine are in this packet.

You should already have received your results for "stress chemicals" in urine, along with results from your saliva sample or wristband if you provided these. Currently, we are analyzing all the study data to learn more about exposures to air pollution in Fresno, Kern and Kings counties. We will share our findings with you and the community when the analyses are done.

What can I learn from FRESSCA-Mujeres about chemicals in my body?

This packet provides the following information for each chemical tested:
- The level found in your urine
- Information on ways you might have been exposed to the chemical
- Actions you could take to help reduce your exposures to the chemical

Continued on the next page ...

FRESSCA
AIRE LIMPIO EN CASA

Agosto 2024

¿Qué se encuentra en este paquete?

1. Acerca del estudio FRESSCA
2. Los resultados de su monitor de aire interior
3. Un resumen sobre la calidad del aire interior de su hogar
4. Recomendaciones
5. Preguntas frecuentes
6. Recursos

Otras noticias:
Recolectamos muestras de orina y saliva al principio y al final del estudio.

El posible que también hayas usado una pulsera que mide los pesticidas.

Todavía estamos analizando las muestras y los datos. Esperamos compartir sus resultados a fines de 2024 o principios de 2025.

Estimada Ana,

Gracias por participar en el proyecto FRESSCA.

El objetivo del estudio era averiguar si los filtros pueden mejorar la calidad del aire interior. Para hacer esto, instalamos monitores de aire dentro de su hogar durante el verano de 2023. También instalamos un filtro encima de su cooler de pantano (cooler evaporativo), un purificador de aire interior o ambos.

Este paquete contiene información sobre la calidad del aire en su hogar. También explica de dónde puede provenir la contaminación del aire y cómo mejorar la calidad del aire interior.

Si tiene preguntas sobre sus resultados o desea obtener más información, comuníquese con nosotros.

Gracias nuevamente por participar en este estudio.

Atentamente,
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¡Comuníquese con nosotros!

Si tiene alguna pregunta o inquietud sobre sus

2. Resultados de su monitor de aire interior (partículas)

¿Qué es el material particulado?

Las partículas en suspensión (PM) son una mezcla de muchos productos químicos y partículas que se encuentran en la contaminación del aire. La contaminación del aire por PM puede variar en tamaño:

- Las partículas pequeñas (llamadas PM2.5) provienen de cosas que se queman, como madera, petróleo y gases de escape de diésel.
- PM10 es una categoría de PM que incluye PM2.5 y partículas más grandes, como polvo, polen y moho.

Las partículas, especialmente las PM2.5, pueden afectar los pulmones y el corazón. Todos estamos expuestos a un poco de PM, pero es importante reducir la exposición cuando sea posible.

¿Cómo era la calidad del aire en su casa? Al usar un filtro de aire, ¿se mejora la calidad del aire interior?

Medimos las partículas en suspensión dentro de su hogar usando monitores de aire durante aproximadamente 70 días. En algunos hogares también instalamos un muestreador pequeño de aire para ayudar a identificar los tipos de partículas.

En promedio, sus niveles de PM2.5 fueron más altos que los del monitor exterior más cercano.

En general, el estudio descubrió que los filtros de cooler como los purificadores de aire interior mejoraron la calidad del aire interior al reducir los niveles de PM10 y PM2.5.

Concentración promedio de $PM_{2.5}$ en interiores y exteriores

Su Casa
Monitor exterior más cercano

17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
µg/m³

16.7
7.3

Casa
Exterior

¿Cuándo hubo mayor cantidad de partículas dentro de su casa?

$PM_{2.5}$ promedio en cada hora

Los niveles de PM en el interior de su hogar pueden cambiar a lo largo del día. El gráfico a la izquierda muestra la cantidad de PM que había habitualmente en el aire a cada hora del día.

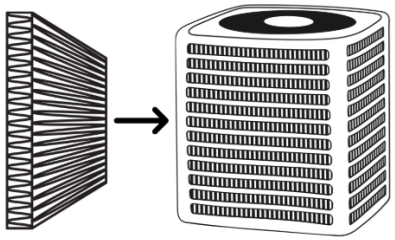
- Los niveles de PM2.5 eran normalmente más altos en su hogar a las 10AM.
- Los niveles de PM2.5 en su hogar eran normalmente más altos en el interior que en el exterior durante unas 8.5 horas al día.

Esta información puede ayudarle a identificar las fuentes de PM2.5 en su hogar. Durante las horas donde los niveles de PM se encuentran altos, ¿qué está cocinando afuera o adentro de su hogar?

Next steps for the FRESSCA-Mujeres project

- Promote ways to reduce exposures in the FRESSCA-Mujeres communities and beyond

Portable air cleaners in homes

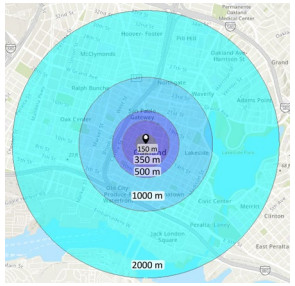


Swamp cooler filters during a wildfire event

Community engagement to reduce exposures to mercury in skin creams, and to arsenic

- Continue research to identify potential exposure sources of naphthalene and other chemicals of interest

Combine data from FRESSCA-Mujeres, BiomSPHERE, and SAPEP to identify trends



Assess geospatial predictors of traffic exposures

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Questions?