Results from the Stockton Air Pollution Exposure Project (SAPEP)

Presentation at the
Biomonitoring California
Scientific Guidance Panel Meeting

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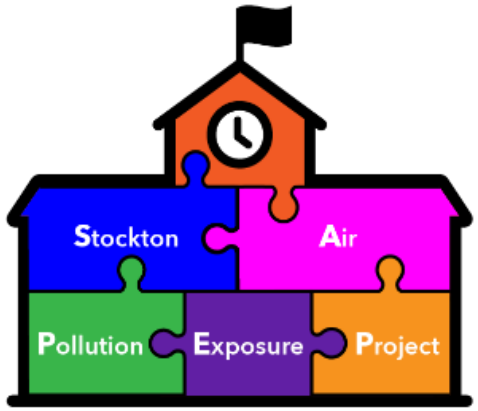
Stockton Air Pollution Exposure Project (SAPEP)

Learn more about air pollution exposures to schoolchildren in Stockton

Evaluate effectiveness of school air filtration at reducing children's air pollution exposures

Overview of study elements



- Enrolled students from All Saints Academy of Stockton
- Measured air pollutant levels inside and outside of the school

- Installed portable air cleaners in ~ half the classrooms of participating students
- Parents completed online questionnaires

- Collected children's urine before and after school
- Measured chemicals that indicate exposure to air pollution

More details available at:
https://www.biomonitoring.ca.gov/sites/default/files/downloads/CommunityBiomUpdate072222.pdf

Sample collection

- Goal to enroll 50 children; actual enrollment = 18
- Total of 69 valid urine samples collected (~4 per child)
  - On two days of consecutive weeks in early December 2021
  - One sample before school, one sample after school

Exposure to Volatile Organic Compounds (VOCs) & Polycyclic Aromatic Hydrocarbons (PAHs)

Analyses of urinary biomarker data showed:

- Nearly ubiquitous exposures to fluorene, naphthalene, phenanthrene, pyrene, acrolein, acrylonitrile, crotonaldehyde, and propylene oxide
- Comparatively less-common exposures to benzene and 1,3-butadiene
- Except for naphthalene, PAH and VOC metabolite levels were comparable to, or lower than, children participating in the National Health and Nutrition Examination Survey (NHANES)*
  - Median level of 2-naphthol (2-NAP), a metabolite of naphthalene, was nearly 4 times as high in SAPEP as in NHANES

* Based on comparison to children ages 5-13 years, participating in the 2015-2016 NHANES, as previously reported: https://www.biomonitoring.ca.gov/sites/default/files/downloads/CommunityBiomUpdate030723.pdf

Naphthalene exposures in SAPEP: a further look

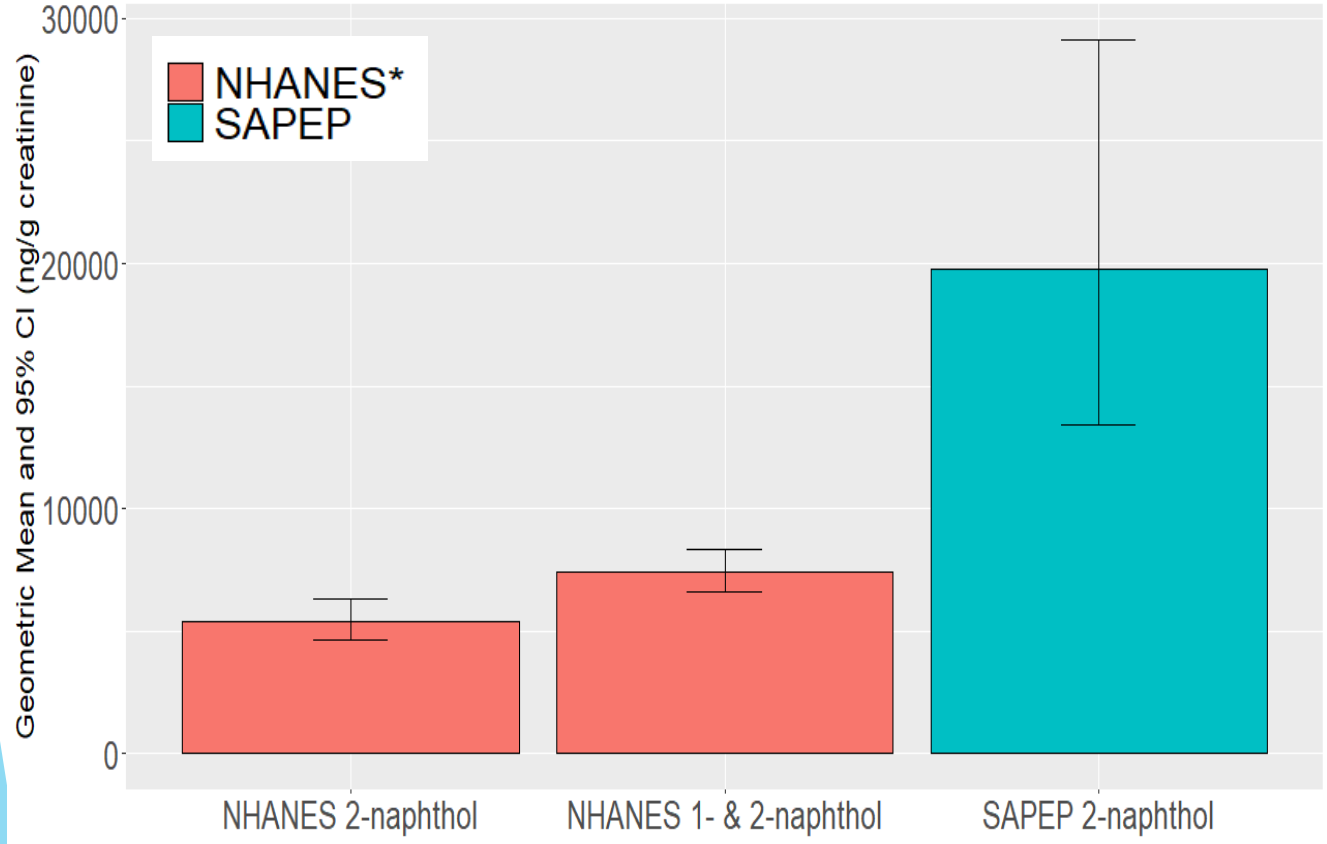
Are exposures truly high? Or could our 2-NAP results be an artifact of:

- Laboratory methods?
- Measurement issues/other factors?

If levels are truly high - why?

- What chemicals were participants exposed to?
- What are possible exposure sources?

SAPEP vs. NHANES: laboratory methods and results



Differences in laboratory methods:

- **NHANES:**
  - Gas chromatography–mass spectrometry (GC-MS)
  - Reported 2-naphthol (2-NAP) & 1-naphthol (1-NAP) separately
- **SAPEP:**
  - Liquid chromatography–mass spectrometry (LC-MS)
  - Reported 2-NAP, but with some co-elution of 1-NAP

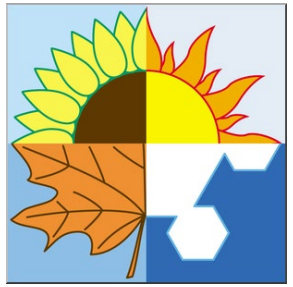
*Children ages 5-13 years, participating in the 2015-2016 NHANES

SAPEP vs. NHANES: different time frames

- **SAPEP samples were collected in 2021, about 5 years after NHANES comparison data**

  - U.S. biomonitoring data suggest a recent upward trend in 2-NAP levels
  - The apparent higher 2-NAP levels in SAPEP may be partially explained by this underlying trend in the general population

- **Naphthalene ambient air concentrations vary by season**



  - SAPEP sampling: conducted in the winter, when naphthalene air concentrations are typically high
  - NHANES sampling: conducted year-round
  - The apparent higher 2-NAP levels in SAPEP may be partially explained by these seasonal differences

SAPEP urinary 2-NAP levels: comparison to other study populations

- Contemporary data on 2-NAP, especially in children, is sparse
- Compared to available data, SAPEP 2-NAP levels appear high

- SAPEP 2-NAP is ~ 2 times higher than a study of smokers, smokeless tobacco users, and e-cig vapers living in the rural Midwest*
  - Samples analyzed by the same method and same laboratory as SAPEP
  - Samples collected during a similar time frame as SAPEP

* Unpublished data, personal communication (Peyton Jacob, UCSF)

Exploring potential exposure sources

Analysis of air & questionnaire data

Analyze air and questionnaire data to help identify factors associated with high 2-NAP levels

Follow-up lab analyses

Separate 1-NAP from 2-NAP to help identify the parent chemical(s) of concern

Geospatial exploration

Identify environmental sampling & monitoring data to help discern potential exposure sources in the community

Share findings with participants & community

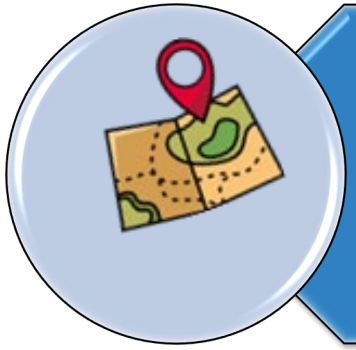
2-NAP potential exposure sources: current findings

Urinary 2-NAP levels might partially be explained by:

- Exposures related to living in a home with an attached garage
- Consumption of fried, grilled, barbequed, smoked, or roasted food

Urinary 2-NAP levels are not likely to be explained by tobacco exposures

- 2-NAP not related to self-reported tobacco exposures
- 2-NAP not related to nicotine metabolites

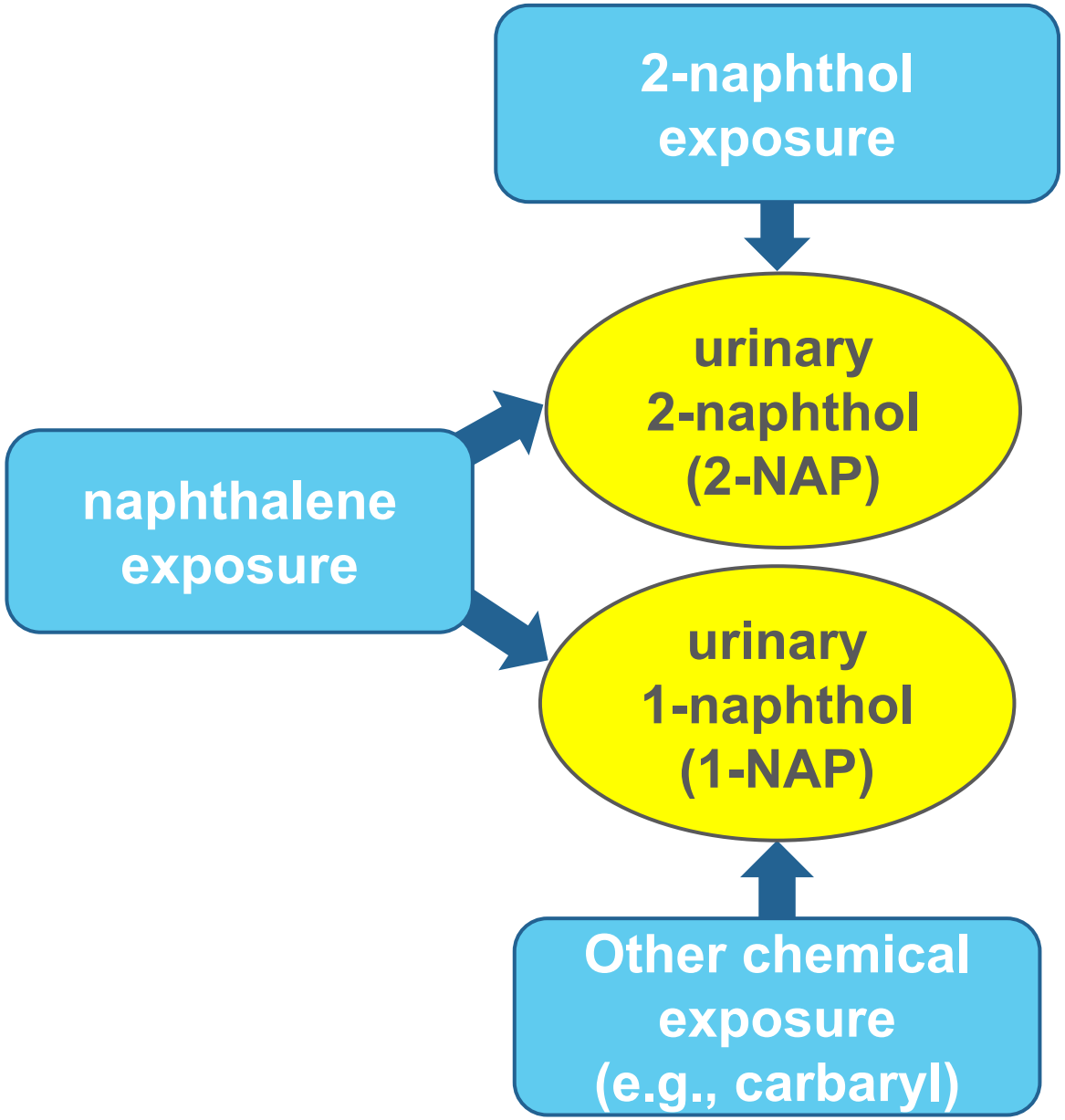


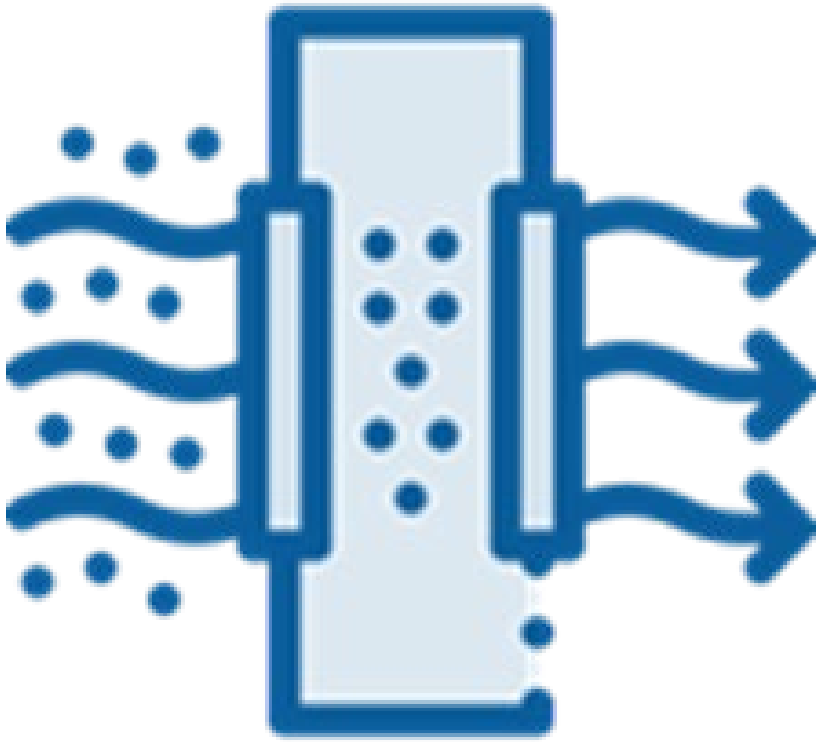
Urinary 2-NAP levels are not likely to be explained by agricultural burning

- No burning in Stockton area during week 1 when air naphthalene levels were highest

Follow-up lab analyses will:

- Separate 1-NAP from 2-NAP
- Help identify potential parent compound(s) of exposure concern

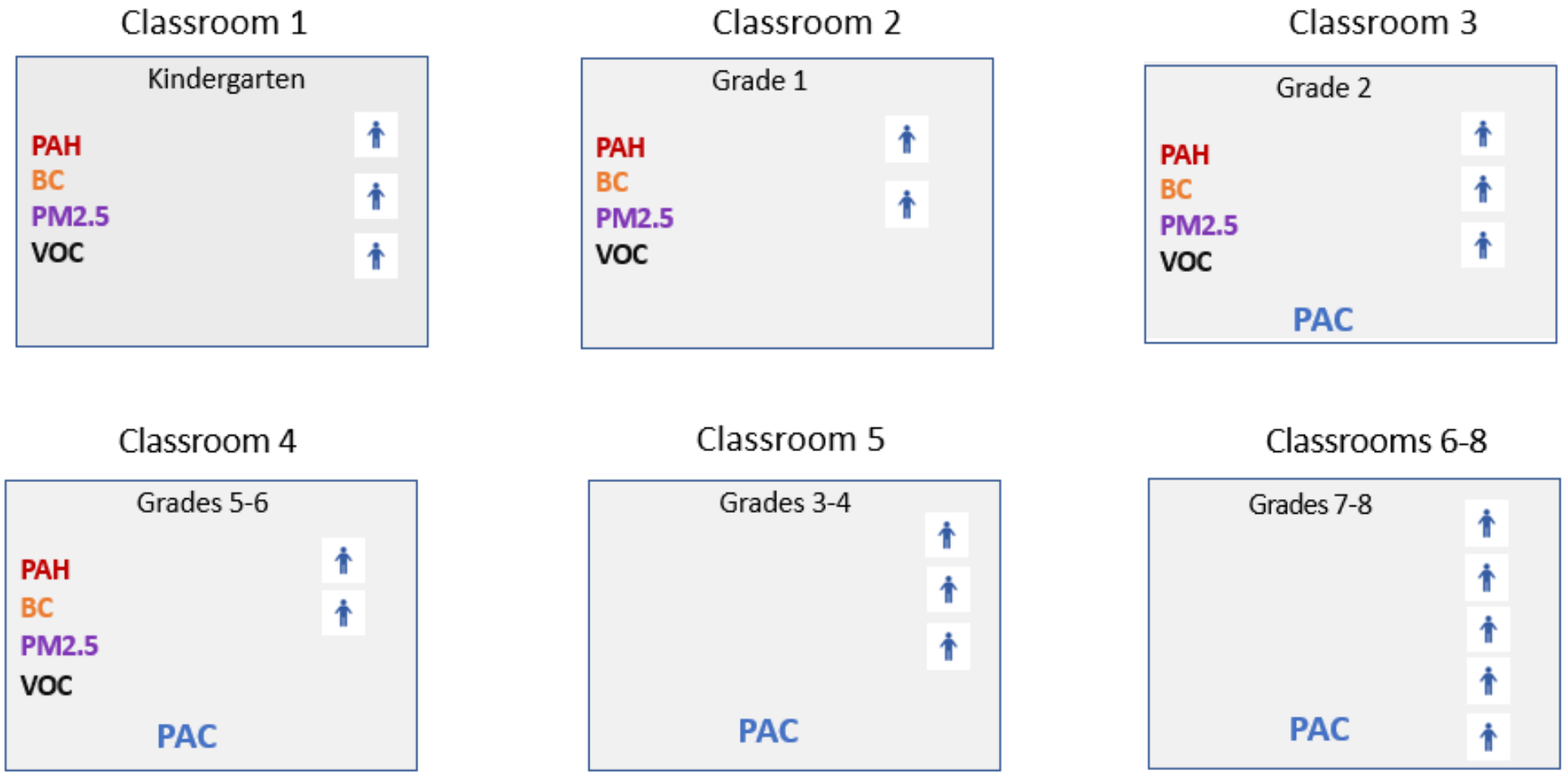




Evaluating the effectiveness of school air filtration at reducing children's air pollution exposures

- Air data
- Biomarker data

Sampling and portable air cleaner locations by classroom



LEGEND

PAH = Polycyclic Aromatic Hydrocarbons

BC = Black Carbon

PM2.5 = Particulate Matter < 2.5 µm in diameter

VOC = VOCs

PAC = Portable air cleaner

= 1 Participant

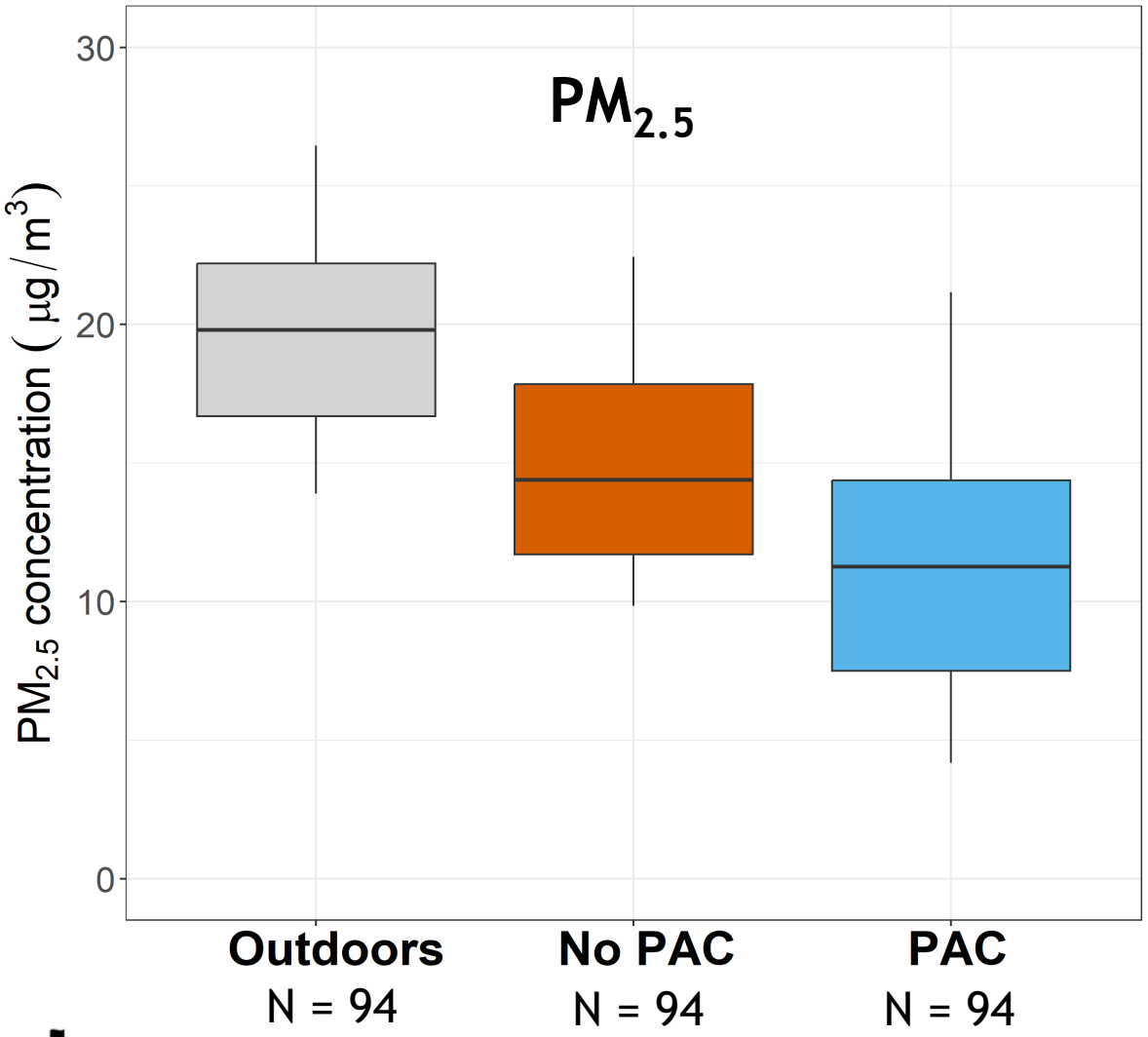
Location of classrooms and portable air cleaners (PACs)*

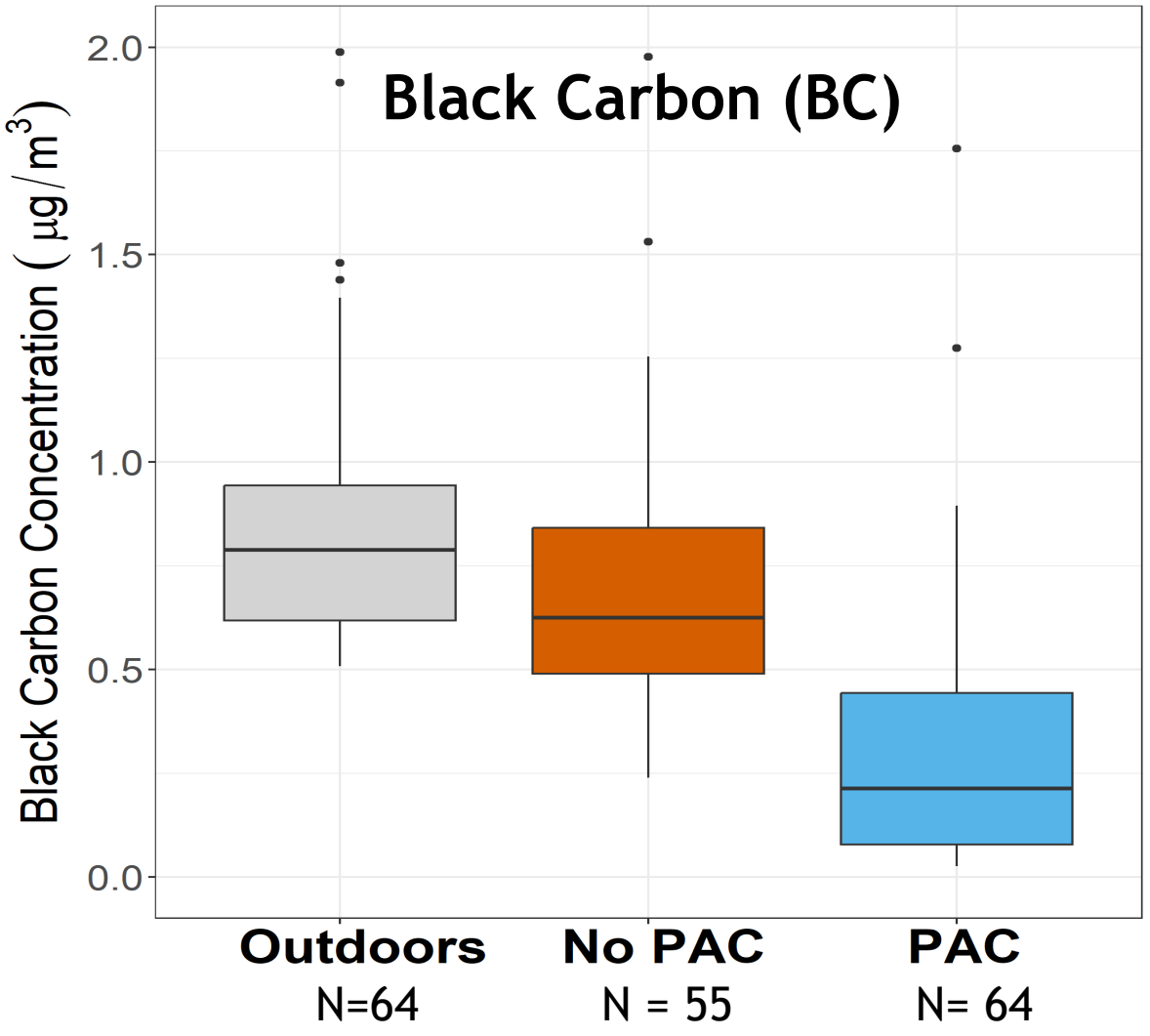
- Classrooms with air quality data:
  - Classrooms 1 & 2: No PAC (both weeks)
  - Classrooms 3 & 4: PAC (both weeks)

- Classrooms with no air quality data:
  - Classrooms 5, 6-8: PAC in week 2

* Portable Air Cleaner (PAC) = IQAir HealthPro Plus

Effect of portable air cleaner (PAC) on air concentrations*





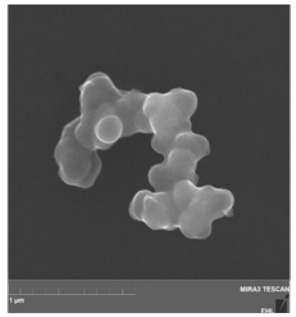
All medians significantly differ (Wilcoxon Rank Sum Test p-value < 0.05)

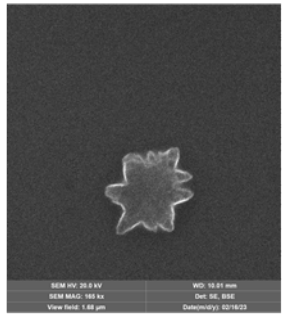
Portable air cleaner = IQAir HealthPro Plus

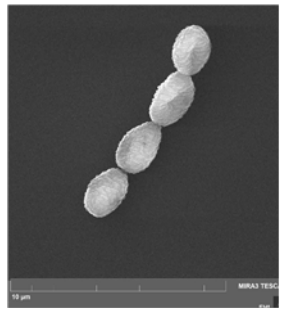
SAPEP: identification of particulate matter types*

- Passive particulate matter (PM) samplers:
  - Deployed in two classrooms and one outdoor location
  - Analyzed using scanning electron microscopy (SEM)

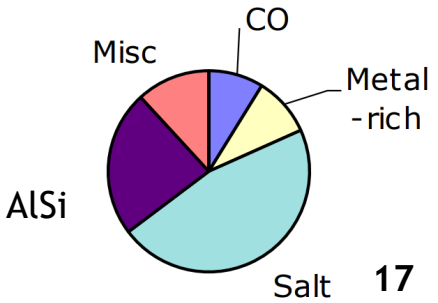
- Major PM types found included:
  - Sodium salt fog particles with sulfur or chlorine
  - Aluminosilicate dusts
  - Fine combustion agglomerates
  - Coarse biogenic particles
  - Fine, metal-rich particles







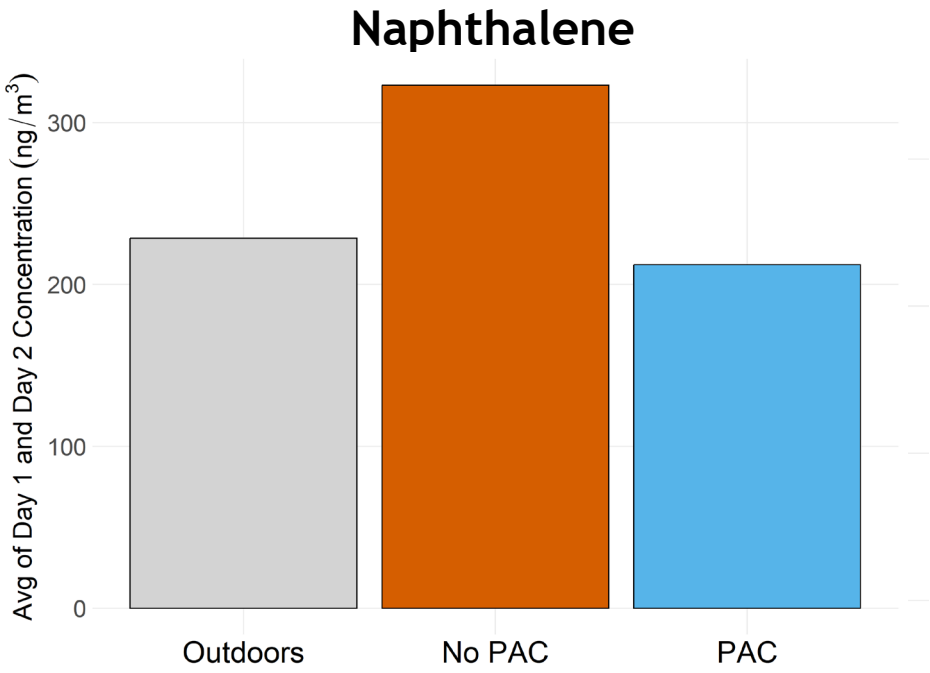
- Passive PM sampling = useful community exposure assessment tool
- Lower concentrations found in classroom with portable air cleaner



* Wagner J, et al., under review (submitted to *Atmosphere),* October 2023

PAH concentrations: outdoors and in classrooms with and without portable air cleaners (PACs)

- 24-hr samples collected on each day of study
  - 2 outdoor locations
  - 2 classrooms with PACs
  - 2 classrooms without PACs
- 17 PAHs measured, includes particle and vapor-phase
- Week 2 levels were very low (due to rainstorm)
- Could not do formal statistical analyses due to small numbers
- For most PAHs, it appeared:
  - Classrooms without PACs had the highest concentrations – higher than classrooms with PACs and higher than outdoors

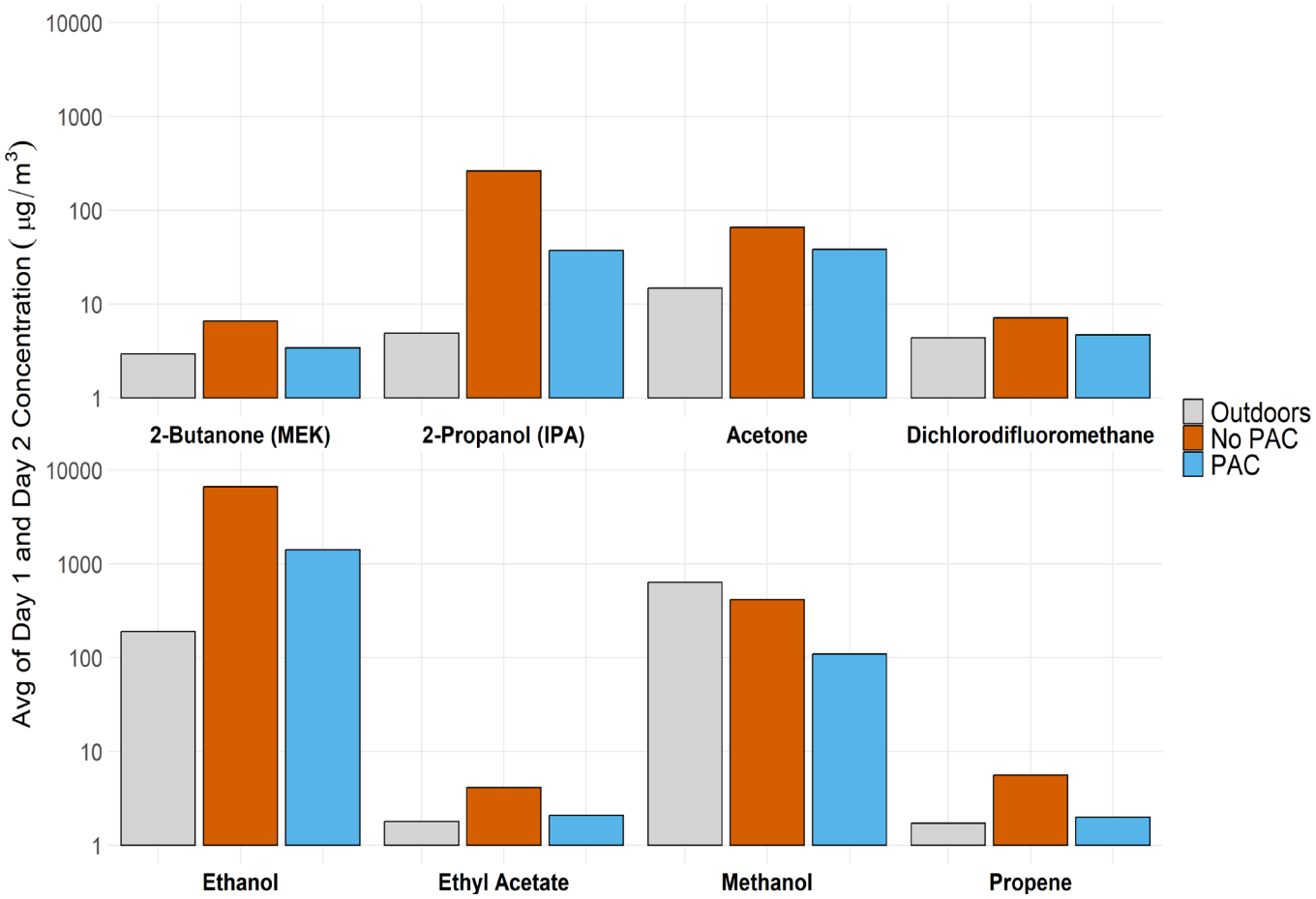


Based on week 1 data:

Outdoors *n = 4 air samples from 2 outdoor locations*
No PAC *n = 4 air samples from 2 classrooms*
PAC *n = 6 air samples from 2 classrooms*

VOC concentrations: outdoors and in classrooms with and without portable air cleaners (PACs)

- 8-hr samples collected on each day
  - 1 outdoor location
  - 2 classrooms with a PAC
  - 2 classrooms without a PAC
- Sampling conducted only during week 2
- Detectable levels reported for 8 of 68 VOC analytes measured (EPA Method TO-15)
- Could not do formal statistical analyses due to small numbers
- Classrooms with a PAC tended to have lower levels than classrooms without a PAC



Effectiveness of portable air cleaners based on PAH metabolite data: regression results*

Parent Compound	PAC Effect**	p-value¥
Fluorene	-52%	0.05
Naphthalene	-89%	0.25
Phenanthrene	-66%	0.12
Pyrene	-91%	0.31

n=32 records (am/pm pairs) from 18 participants

Pattern suggests portable air cleaners may reduce PAH exposures

* Estimated from model: $\log_2$(pm metabolite level) = $\beta 0 + \beta 1 * \log_2$(am metabolite level) + $\beta 2$*(PAC) + error

** PAC Effect: represents the % change in metabolite level associated with the PAC, adjusting for am (before school) level

¥ p-value for a one-sided t-test, testing for $\beta 2 < 0$)

Effectiveness of portable air cleaners based on VOC metabolite data: regression results*

Parent Compound	PAC Effect**	p-value¥
Acrolein	147%	0.98
Acrylonitrile	137%	0.78
Crotonaldehyde	-98%	0.45
Propylene oxide	175%	0.99

n=32 records (am/pm pairs) from 18 participants

No consistent effect of portable air cleaner on reducing VOC exposures

* Estimated from model: $\log_2$(pm metabolite level) = $\beta 0 + \beta 1 * \log_2$(am metabolite level) + $\beta 2$*(PAC) + error

** PAC Effect: represents the % change in metabolite level associated with the PAC, adjusting for am (before school) level

¥ p-value for a one-sided t-test, testing for $\beta 2 < 0$)

Note: Models not run for metabolites of benzene and 1,3-butadiene due to low detection frequencies (< 65%)

Evaluation of air filtration: overall summary

- The use of a portable air cleaner:
  - Modestly reduced the concentration of $PM_{2.5}$ and black carbon in **classroom air**
  - May have reduced the concentration of some PAHs and VOCs in **classroom air**
- The degree to which these reductions in air concentrations reduced children's **overall exposures** to PAHs and VOCs is difficult to ascertain due to study limitations

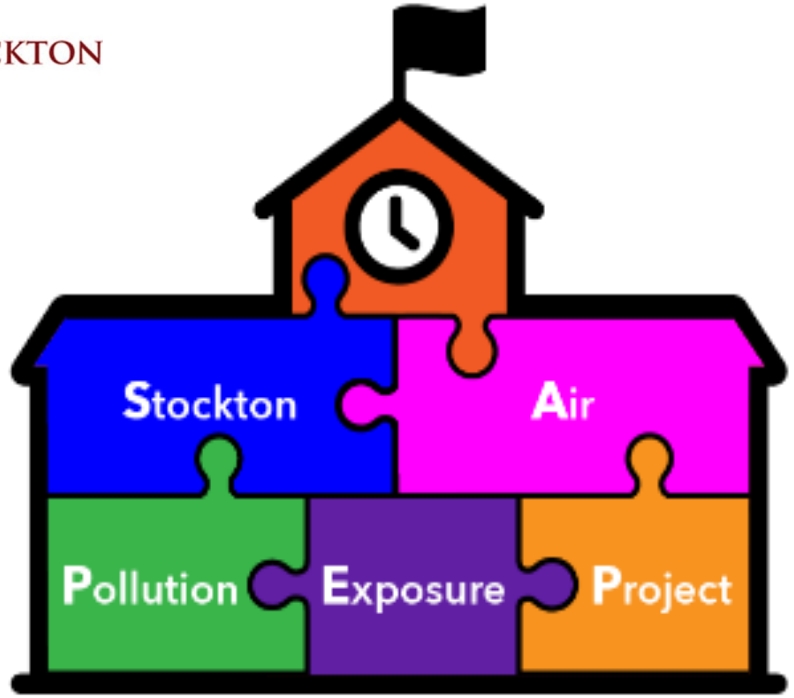
Limitations

- Small number of participants
- Smaller than expected reductions in pollutant concentrations from portable air cleaners
- Lower than expected ambient air pollution (due to rain)
- “Noisy” data - variability in HVAC systems/ventilation conditions across classrooms
- Pandemic conditions – open doors, all children wore masks while at school

Limited statistical power to detect effects

Successes and future directions

- We refined methods and tools for community air pollution biomonitoring studies
  - Kits for DIY urine sample collection by children in their homes
  - Electronic return of individual results to participants
- We helped build community capacity to reduce air pollution exposures
  - Participants were provided with information about their exposures and tips for reducing exposures
  - The school was provided with portable air cleaners and Purple Air monitors
- SAPEP results, in combination with those from our ongoing community biomonitoring studies, will provide insights into the utility of these biomarkers for understanding air pollution exposures



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