Results from the Biomonitoring component of the San Joaquin Valley Pollution and Health Environmental Research Study (BiomSPHERE)

Biomonitoring California Scientific Guidance Panel Meeting

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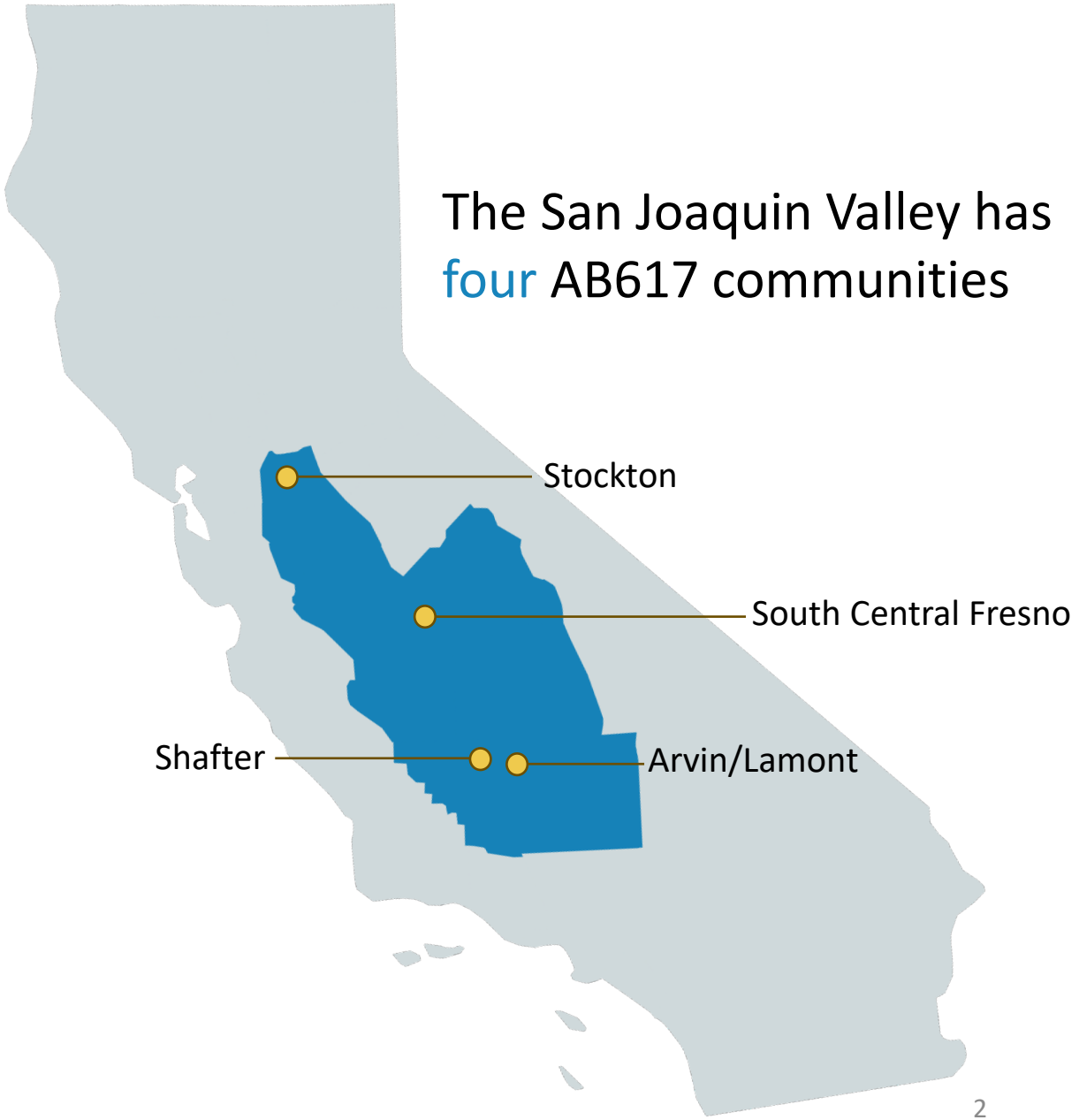
Air Pollution in the San Joaquin Valley

The San Joaquin Valley has four AB617 communities

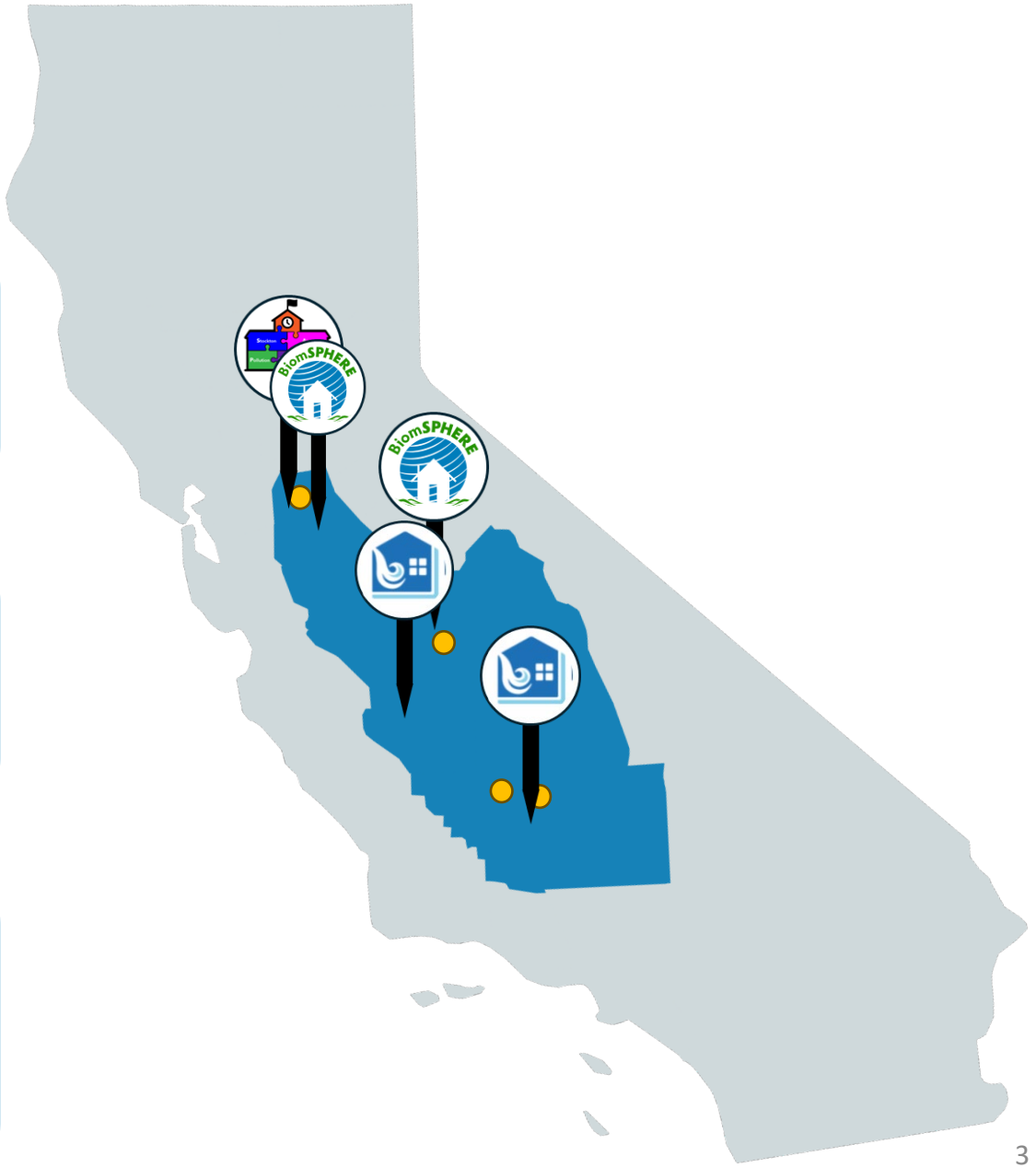


Biomonitoring CA Studies in the San Joaquin Valley

Stockton **A**ir **P**ollution **E**xposure **P**roject (SAPEP)

Farmworker women & **R**espiratory **E**xposure to **S**moke from **S**wamp **C**ooler **A**ir (FRESSCA-Mujeres)

Biomonitoring component of the **S**an Joaquin Valley **P**ollution and **H**ealth **E**nvironmental **Re**search Study (BiomSPHERE)



Study Goals

San Joaquin Valley Pollution and Health Environmental Research (SPHERE) Study*

Air pollutants and noise exposure in Fresno and Stockton

BiomSPHERE added a biomonitoring component to SPHERE

- Air pollution exposures in Stockton and Fresno using biomonitoring
- Differences in exposures between individuals, within individuals over time, and across the two communities
- Provide comparative data to our other studies in the San Joaquin Valley

*Funded by California Air Resources Board, Contract # 20RD012

BiomSPHERE Participants

64 families

Spanish and English speakers

Households in Stockton (N = 12) and Fresno (N = 52)

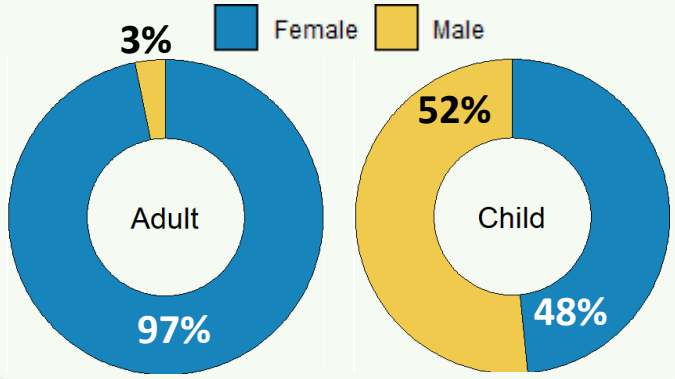
February to November of 2023

Demographics (N = 64 families)

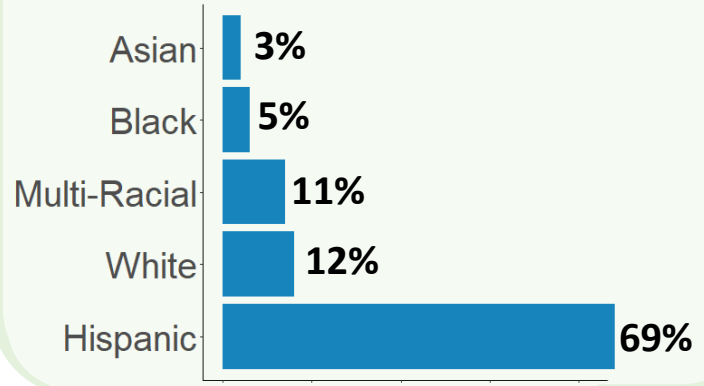
Age (Mean ± SD)

Adult	Child
42	**9**
± 7.6	± 2.3

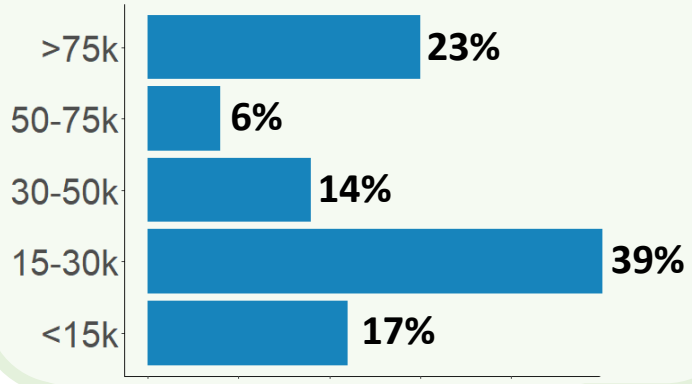
Sex (%)



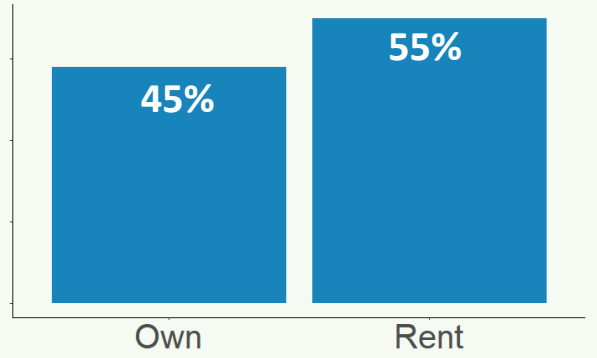
Race and/or Ethnicity (%)



Household Income (%)

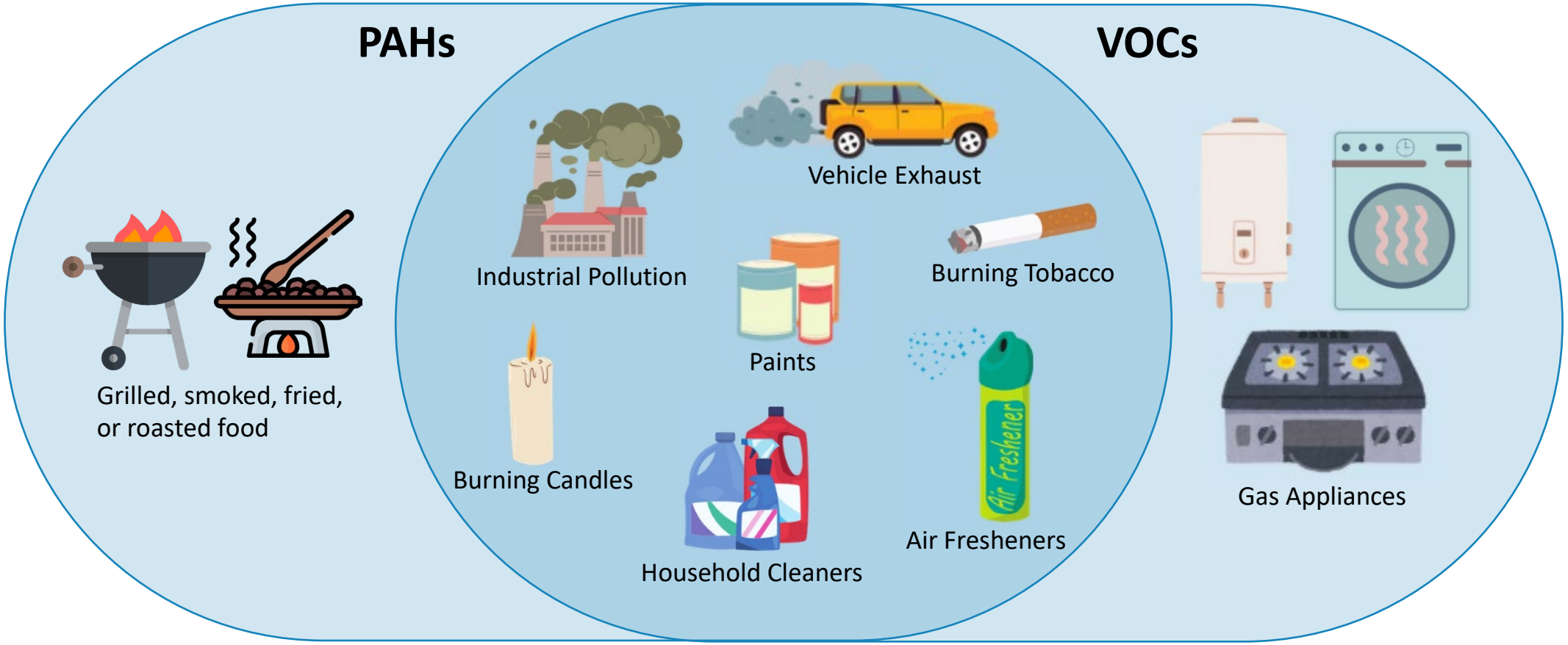


Home Ownership (%)



Air Pollutants

Polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) are known to be major components of indoor and outdoor air pollution



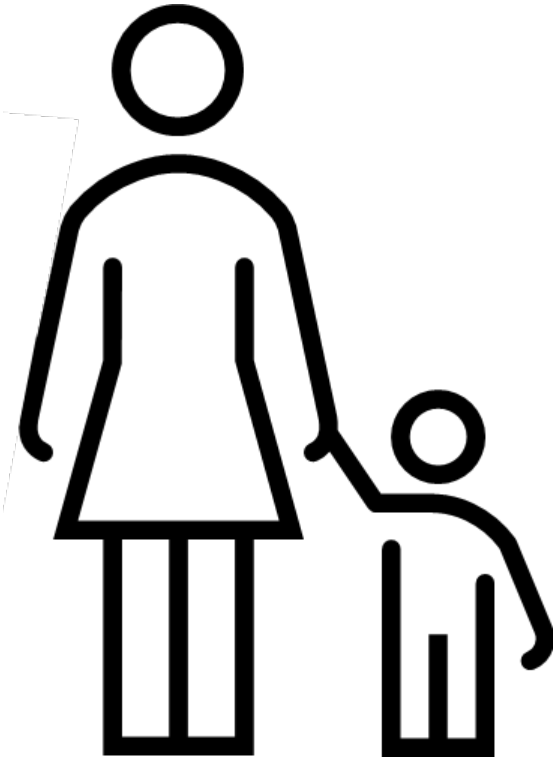
Air Monitoring

- Air monitoring conducted for 24 hours. Matched indoor and one outdoor sample collected from each home

- Air measurements:
  - 36 PAHs
  - Criteria air pollutants ($PM_{2.5}$, ozone, nitrogen dioxide, carbon monoxide)
  - Black carbon
  - VOCs

- Four PAHs overlapped with urinary analytes
  - Naphthalene (NAP)
  - Fluorene (FLU)
  - Phenanthrene (PHE)
  - Pyrene (PYR)

Biomonitoring



- First morning void urine sample
- For a subset of 8 families, daily samples were collected over four consecutive days
- Urinary analytes:
  - Metabolites of PAHs and VOCs
  - Biomarkers of oxidative stress and inflammation
  - Cotinine

Data Analysis

Air Monitoring

- Values below limit of detection (LOD) were imputed: LOD/$\sqrt{2}$

- Indoor-to-outdoor (I/O) PAH ratio was calculated when **at least one** of the indoor or outdoor PAH measurements in each household was > LOD
- Univariate **linear models** used to examine associations with biomarkers

Biomonitoring in Urine

- Values below LOD were imputed: LOD/$\sqrt{2}$
- **Creatinine** adjusted values for comparison with NHANES concentrations
- **Specific gravity (SG)** adjusted and **log transformed** values for statistical analysis
- Urine sample **closest** in time to the questionnaire was selected for associations

- **Linear models** used to examine associations with questionnaire data

PAH Results

PAHs in Air

		NAP	FLU	PHE	PYR
Indoor	**N**	59	57	57	32
	Detection Freq	56%	5%	18%	16%
Outdoor	**N**	51	51	51	30
	Detection Freq	35%	10%	20%	20%

- Naphthalene is the most frequently detected PAH; this is consistent with other studies

		NAP	FLU	PHE	PYR
Indoor/Outdoor Ratio	**N** (Indoor/Outdoor Pair)	27	6	11	7
	Ratio	2.6	0.78	1.1	1.4

- The average indoor-to-outdoor ratio (I/O) was highest for naphthalene

PAH Metabolites in Urine

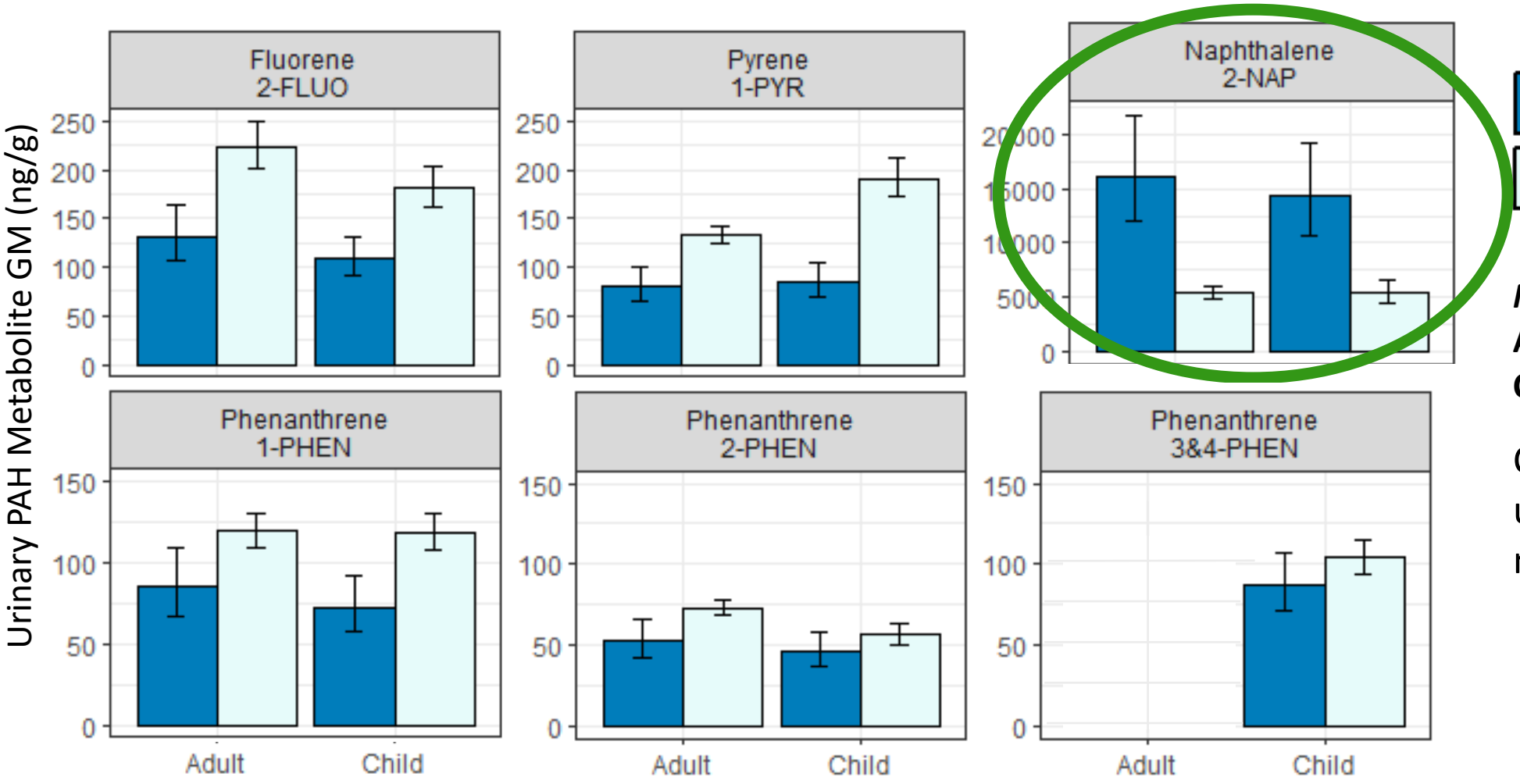
Parent Compound	Metabolite*	Adult (N = 64)		Child (N = 64)	
		Detection Frequency (%)	Median (ng/g)	Detection Frequency (%)	Median (ng/g)
Fluorene	1-FLUO	52	33	47	31
	2-FLUO	94	132	92	118
	3-FLUO	45	NC	48	NC
Naphthalene	1-NAP	53	361	44	NC
	2-NAP	100	14900	100	14500
Phenanthrene	1-PHEN	91	85.6	86	75.3
	2-PHEN	69	53.3	69	43.8
	3- & 4-PHEN	56	80.8	72	80.9
Pyrene	1-PYR	88	82.3	88	79.8

NC: Not calculated due to low detection frequency

Medians include data that were imputed and adjusted for creatinine

*Full chemical names are provided in the glossary included at the end of this presentation

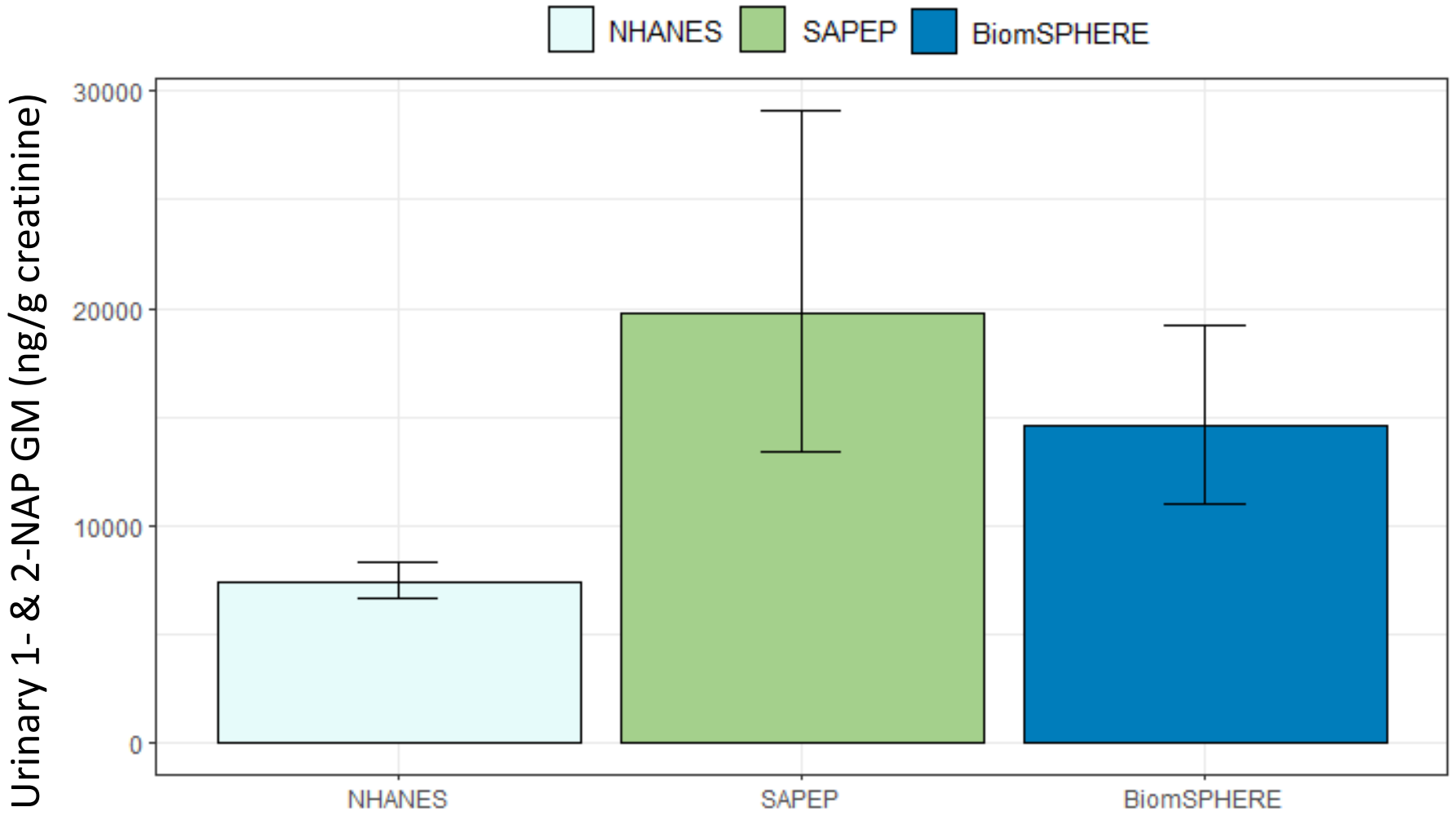
PAHs in BiomSPHERE vs NHANES



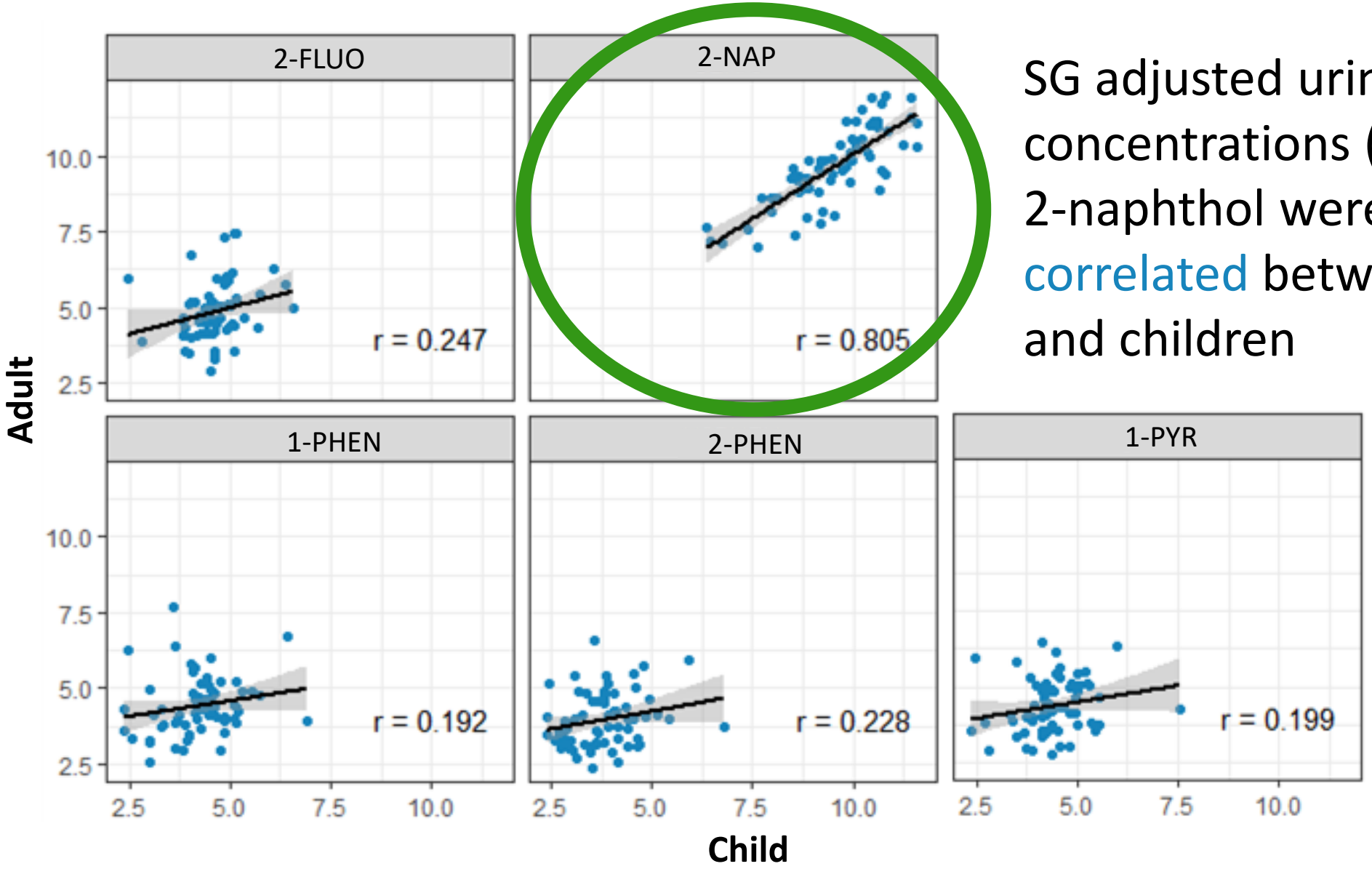
NHANES Age Groups:
Adults: 20+ years
Children: 6-11 years

Creatinine adjusted urinary geometric means (ng/g)

1- & 2-NAP in Children Across Studies



PAH metabolites in Adults vs Children



SG adjusted urinary concentrations (ng/L) for 2-naphthol were strongly correlated between adults and children

Temporal Variability in PAH Metabolite Levels

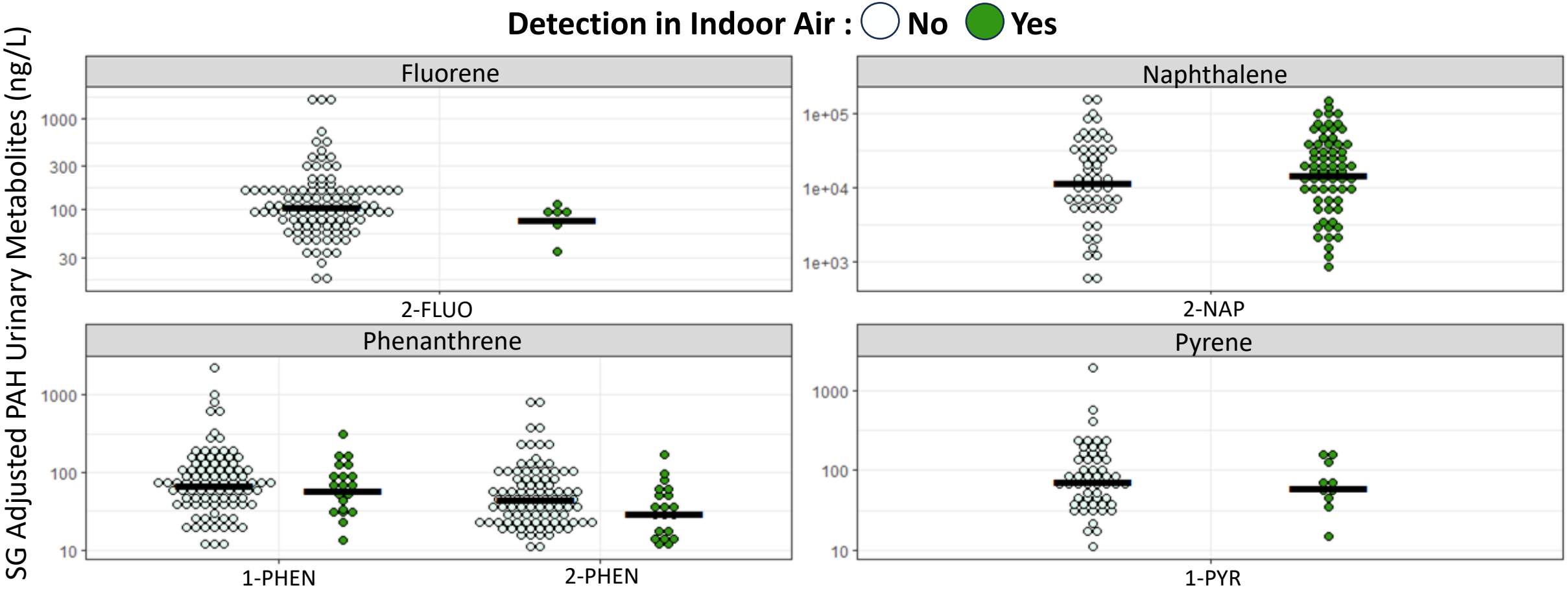
	2-FLUO	2-NAP	1-PYR	1-PHEN
Adult	0.84	0.94	0.79	0.07
Child	~0.00	0.88	0.40	0.25

Intraclass correlation coefficients for SG adjusted urinary concentrations (ng/L)

Intraclass Correlation Coefficient:
Less than 0.5 are indicative of poor repeatability
Between 0.5 and 0.75 indicate moderate repeatability
Between 0.75 and 0.9 indicate good repeatability
Greater than 0.90 indicate excellent repeatability

- 8 families provided daily samples over multiple consecutive days (N = 31)
- 2-NAP, 2-FLUO, and 1-PYR had good or excellent repeatability in adults
- 2-NAP had good repeatability in children
- Suggests consistent exposure

PAHs in Indoor Air and PAH Metabolites



- Using linear models, no significant associations were found between detection of PAHs in indoor air (Yes/No) and their corresponding urinary metabolites ($p < 0.05$)
- Suggests indoor air is not a significant contributor to metabolite levels

Selected questions:

Pre-Sampling Questionnaire

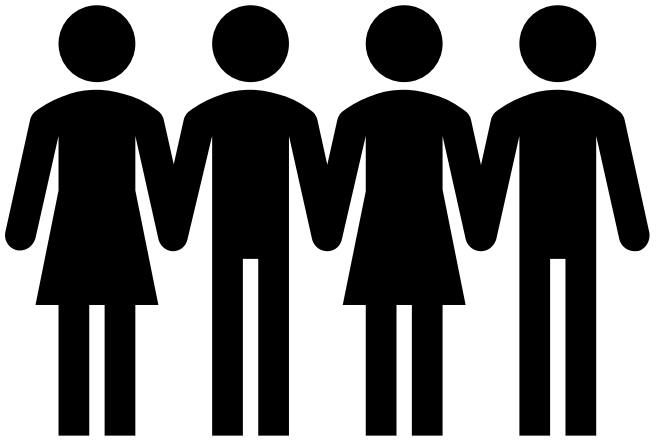
- ❑ Race/Ethnicity
- ❑ Sex
- ❑ Household Income
- ❑ Home Ownership
- ❑ Attached garage
- ❑ City

Post-Sampling Questionnaire

During the past two days:

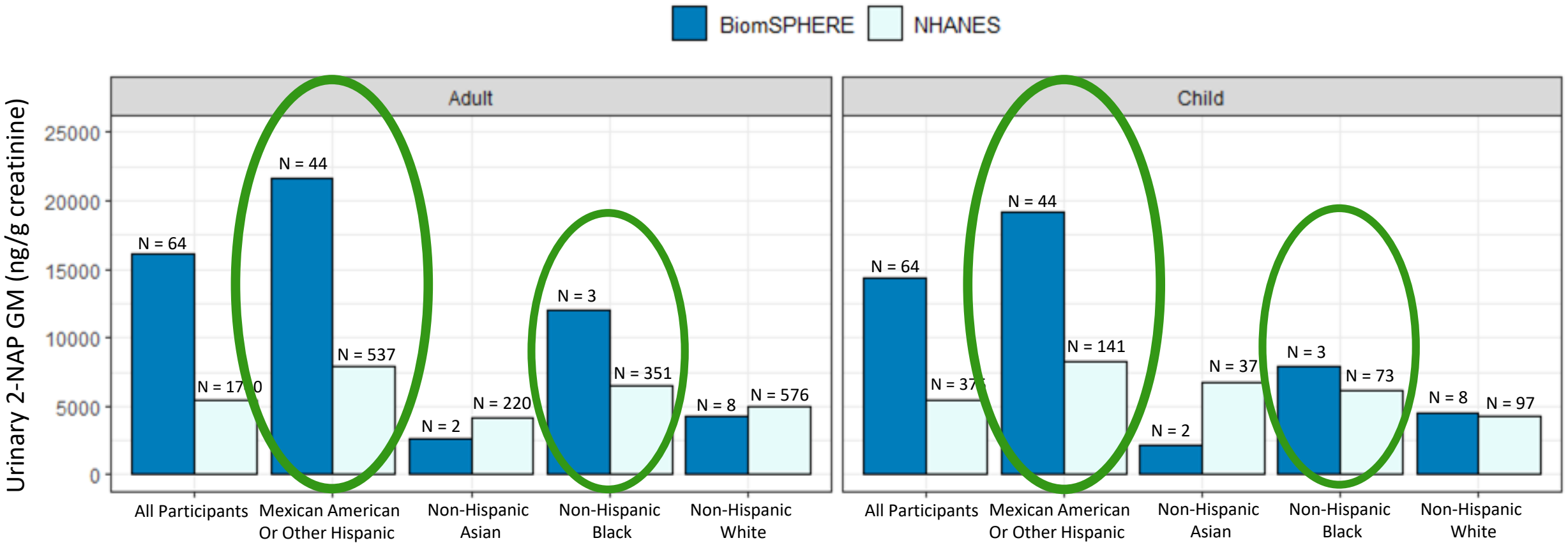
- ❑ Cleaning products
- ❑ Air fresheners
- ❑ Gas stove
- ❑ Personal care products
- ❑ Grilled food consumption

Urinary 2-NAP Associations with Race/Ethnicity and City of Residence



- Levels were approximately 3 times higher in Hispanic/Latino participants compared to non-Hispanic/Latino participants
- After adjusting for race/ethnicity, there were no significant differences in PAH levels between Fresno and Stockton

2-NAP Compared to NHANES by Race/Ethnicity



Creatinine adjusted urinary concentrations (ng/g) for 2-naphthol were higher in BiomSPHERE Hispanic/Latino and Black participants compared to NHANES

After adjusting for race/ethnicity, 2-NAP was significantly and positively associated with:

Products	Percent Used	Effect Estimate	
		Adults	Children
All-purpose spray or aerosol cleaners	34%	**2.3**	**2.2**
Carpet or upholstery cleaner	13%	1.2	**2.5**
Any air fresheners	64%	**1.8**	**2.2**
Air fresheners spray	48%	1.3	**1.9**
Plug in air fresheners	42%	**3.9**	**3.2**
Perfume	64%	**2.3**	Not reported

Contribution of Product Use to 2-NAP Levels

- We saw non-significant positive associations between other scented products use and 2-naphthol

- After accounting for reported product use, urinary 2-naphthol levels were still approximately 3 times higher in Hispanic/Latino populations

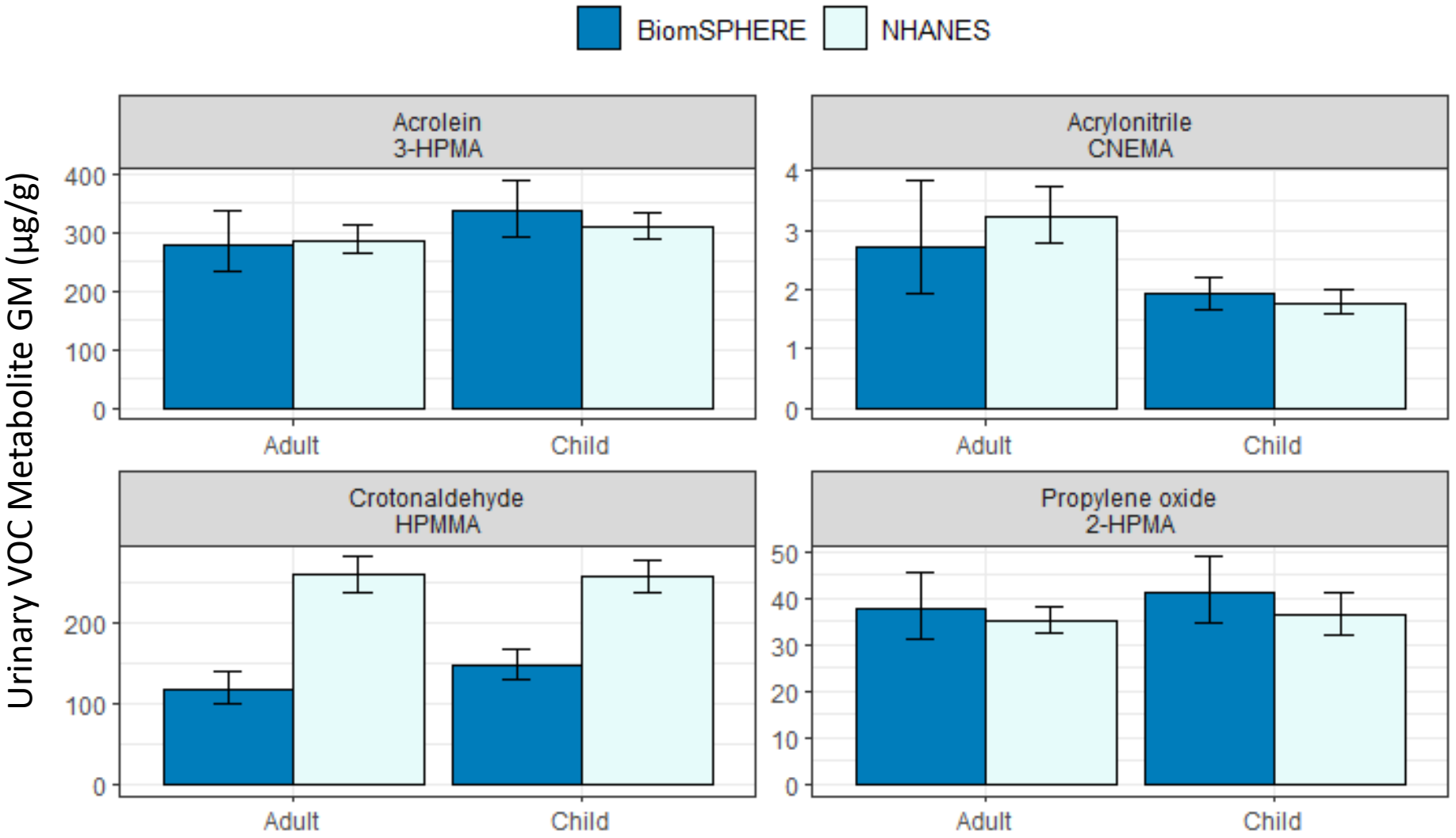
VOC Results

VOC Metabolites in Urine

Parent Compound	Metabolite*	Adult (N = 64)		Child (N = 64)	
		Detection Frequency (%)	Median (µg/g)	Detection Frequency (%)	Median (µg/g)
Acrolein	3-HPMA	100	293	100	331
Acrylonitrile	CNEMA	92	1.79	94	1.88
Benzene	PMA	31	NC	31	NC
1,3-Butadiene	1- & 2-MHBMA	6	NC	3	NC
Crotonaldehyde	HPMMA	100	101	100	138
Propylene oxide	2-HPMA	100	38.1	100	39.1

NC: Not calculated due to low detection frequency
Medians include data that were imputed and adjusted for creatinine
*Full chemical names are provided in the glossary included at the end of this presentation

VOCs in BiomSPHERE vs NHANES



NHANES Age Groups:
Adults: 20+ years
Children: 6-11 years

Creatinine adjusted urinary geometric means (µg/g)

Temporal Variability in VOC Metabolite Levels

	HPMMA	2HPMA	3HPMA	CNEMA
Adult	0.75	0.60	0.72	0.89
Child	0.35	0.46	0.53	0.52

Intraclass correlation coefficients for adjusted urinary concentrations (µg/L)

Intraclass Correlation Coefficient:
Less than 0.5 are indicative of poor repeatability
Between 0.5 and 0.75 indicate moderate repeatability
Between 0.75 and 0.9 indicate good repeatability
Greater than 0.90 indicate excellent repeatability

- 8 families gave daily samples over multiple consecutive days (N = 31)
- VOC metabolites had moderate to good repeatability in adults suggesting consistent exposure

Associations with Questionnaire Data

- No significant positive associations with any VOC metabolites
  - BiomSPHERE did not measure BTEX metabolites that showed significant associations with gas appliances and candle use in EBDEP
- The CDC panel (used in EBDEP) may include more relevant VOC metabolites to our exposures of interest
  - EHL has recently developed these capabilities

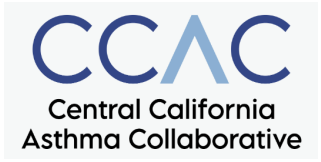
Overall Conclusions

- No significant associations between detection of PAHs in indoor air and their corresponding urinary metabolites
- Most levels of PAH and VOC metabolites in urine were similar to or lower than NHANES, except for 2-naphthol
- Correlations between adults and children and excellent repeatability of 2-naphthol suggest a common and consistent source of naphthalene
- Urinary 2-naphthol was significantly higher in Hispanic/Latino participants
- Urinary 2-naphthol was positively associated with household cleaning products, air fresheners, and perfumes

Next Steps

- Community meeting in the fall
- Additional analyses:
  - Evaluate associations between biomarkers of exposure and biomarkers of response
  - Combine data from SAPEP, FRESSCA-Mujeres, and BiomSPHERE studies to identify:
    - Potential sources of naphthalene
    - Optimal biomarkers for air pollution exposures

Thank you to our participants and project collaborators!



Glossary

Abbreviation	Name	Synonyms used by the National Health and Nutrition Examination Survey (NHANES): https://www.cdc.gov/nchs/nhanes/
Polycyclic Aromatic Hydrocarbon (PAH) metabolites		
1-FLUO	1-Hydroxyfluorene	
2-FLUO	2-Hydroxyfluorene	
3-FLUO	3-Hydroxyfluorene	
1-NAP	1-Hydroxynaphthalene	1-Naphthol
2-NAP	2-Hydroxynaphthalene	2-Naphthol
1-PHEN	1-Hydroxyphenanthrene	
2-PHEN	2-Hydroxyphenanthrene	
3-PHEN and 4-PHEN	3-Hydroxyphenanthrene and 4-Hydroxyphenanthrene	
1-PYR	1-Hydroxypyrene	
Volatile Organic Compound (VOC) metabolites		
3-HPMA	3-Hydroxypropyl mercapturic acid	N-Acetyl-S-(3-hydroxypropyl)-L-cysteine
CNEMA	2-Cyanoethyl mercapturic acid	N-Acetyl-S-(2-cyanoethyl)-L-cysteine
PMA	Phenylmercapturic acid	N-Acetyl-S-(phenyl)-L-cysteine
1-MHBMA and 2-MHBMA	1-Hydroxy-3-buten-2-yl-mercapturic acid and 2-Hydroxy-3- buten-1-yl-mercapturic acid	N-Acetyl-S-(1-hydroxymethyl-2-propenyl)-L-cysteine and N-Acetyl-S-(2-hydroxy-3-butenyl)-L-cysteine
HPMMA	3-Hydroxy-1-methyl-propyl mercapturic acid	N-Acetyl-S-(3-hydroxypropyl-1-methyl)-L-cysteine
2-HPMA	2-Hydroxypropyl mercapturic acid	N-Acetyl-S-(2-hydroxypropyl)-L-cysteine