Initial Results from the East Bay Diesel Exposure Project

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EBDEP Study Team

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UNIVERSITY of WASHINGTON

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Thank you to our supporting partners

Lawrence Berkeley Lab:

Thomas Kirchstetter, Chelsea Preble, Rebecca Sugrue

West Oakland Environmental Indicators Project:

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Project Goals

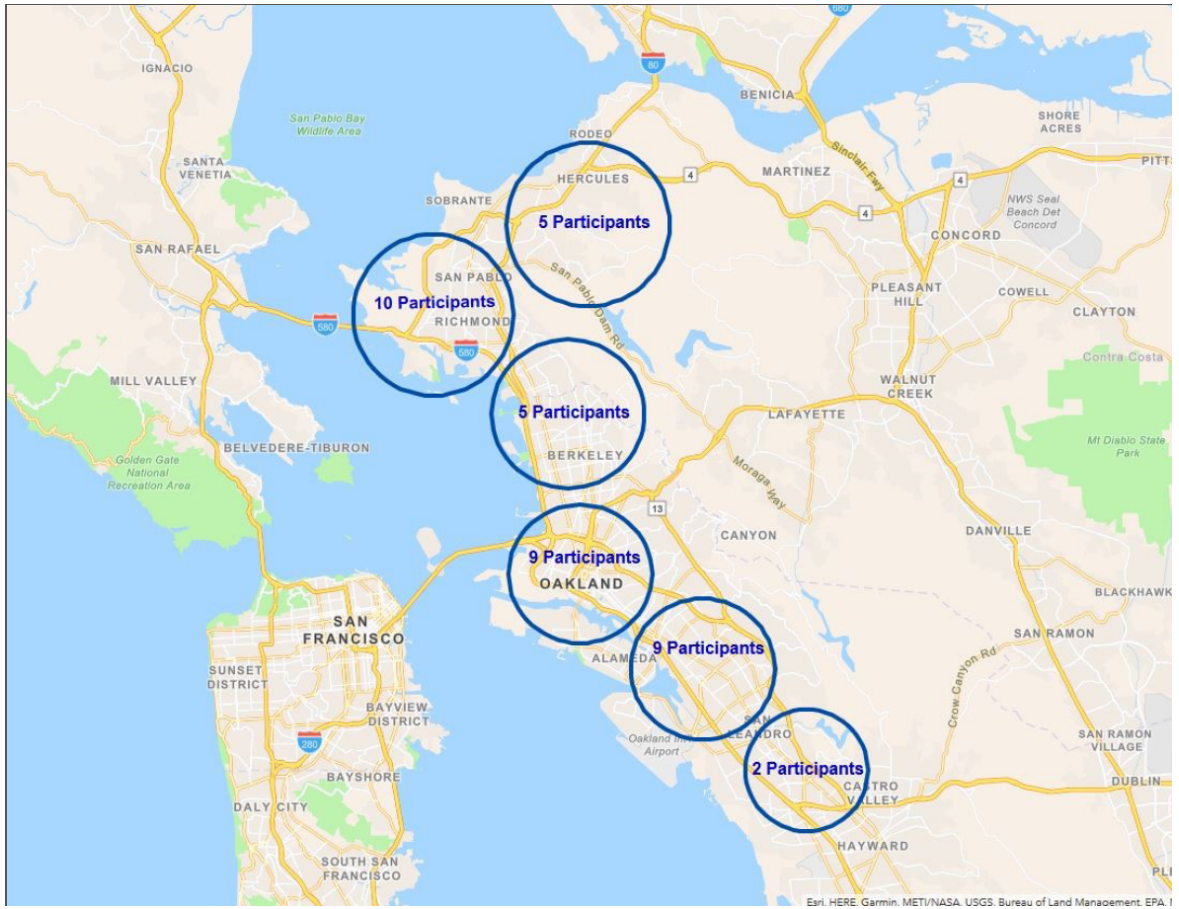
- Assess exposures to diesel exhaust in impacted communities of the East Bay
- Compare exposures in parent-child pairs to increase understanding of exposure patterns:
  - Within a household
  - Over time
  - Between communities
- Evaluate predictors of diesel exhaust exposure, such as truck traffic

- Generate data to help evaluate the effectiveness of diesel regulations in California
- Engage with community and policymakers about study results

EBDEP Locations

East Bay

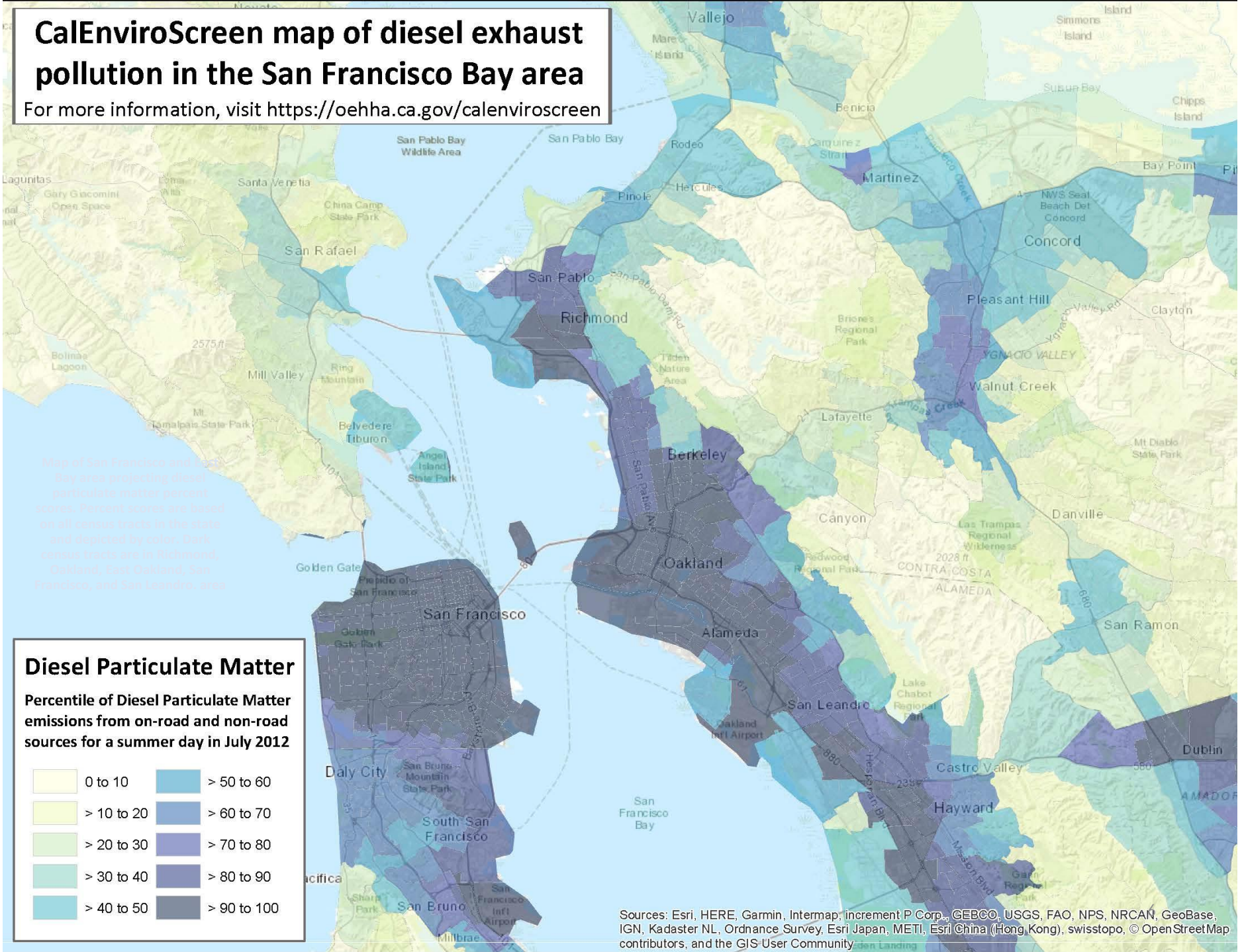
- Oakland
- Richmond
- Other locations along freeways (I-80, I-580, I-880)
- 40 families



Choice of locations informed by CalEnviroScreen diesel particulate matter indicator

CalEnviroScreen map of diesel exhaust pollution in the San Francisco Bay area

For more information, visit https://oehha.ca.gov/calenviroscreen



Diesel Particulate Matter

Percentile of Diesel Particulate Matter emissions from on-road and non-road sources for a summer day in July 2012

0 to 10	> 50 to 60
> 10 to 20	> 60 to 70
> 20 to 30	> 70 to 80
> 30 to 40	> 80 to 90
> 40 to 50	> 90 to 100

CalEnviroScreen Diesel PM Emissions and Scores - EBDEP Summary

	Median	25th percentile	75th percentile	Range
Daily diesel PM emissions (kg/day)	33	21	43	3-76
Diesel PM indicator score	88	74	94	9-99

Notes: CalEnviroScreen data is reported at the census tract level. The above values are based on participants' home addresses.

PM: particulate matter

CalEnviroScreen Diesel PM and Scores in Selected EBDEP Study Areas

Location	N	Diesel PM (kg/day) Range	Diesel PM Indicator Score Range
El Sobrante	3	3 - 15	9 - 45
Pinole	3	11 - 18	31 - 53
Richmond	9	17 – 44	52 - 95
West Oakland	8	76	99
East Oakland	10	19 - 51	59 - 96

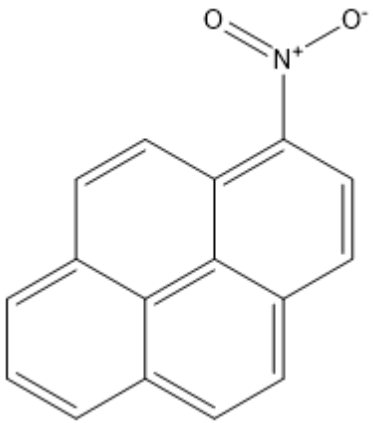
*Based on home addresses of participants

1-Nitropyrene (1-NP)

- 1-NP is formed during combustion by nitration of polycyclic aromatic hydrocarbons (PAHs) within diesel engines
  - 1-NP is the most abundant particle-associated nitro-PAH in diesel exhaust

- More specific than other diesel exhaust exposure indicators (e.g., black carbon)

- Metabolites of 1-NP can be measured in urine as an exposure biomarker
  - 6-hydroxy-1-nitropyrene (6-OHNP)
  - 8-hydroxy-1-nitropyrene (8-0HNP)



Scheepers et al. 1995; Toriba et al. 2007

Study Design

- Forty child-parent pairs
  - Children 2-10 years old
- Urine, indoor air, and vacuum bag/canister dust
- Two sampling rounds for each household, ~4-6 months apart
  - 25 families collected single urine samples for each round
  - 15 families collected daily urine samples for four days for each round
- Field work conducted between January 2018 and February 2019

Data Collection and Laboratory Measurements

- Exposure questionnaire, activity diary, home visit
- GPS data logger for child
- Urinary biomarkers - 1-NP metabolites
  - 6-OHNP
  - 8-0HNP
- Environmental measurements: 1-NP in indoor air and dust
- Indoor monitoring of black carbon using sensor developed by Lawrence Berkeley Laboratory

GPS Data Logger

Latest EBDEP Timeline

- February 2019

  Last samples collected and sent to University of Washington (UW) for analysis

- June-July 2019

  Results return materials submitted to and approved by Institutional Review Boards

- October 2019

  Final datasets for urinary 1-NP metabolites and 1-NP in air filters and dust received from UW

  All results returned to participants

- November 2019

  Preliminary statistical analyses completed

- December 2019-January 2020

  Community meetings planned

Overview of analyses presented today

- EBDEP demographics and selected exposure characteristics
- Urinary 1-NP metabolite levels
  - Summary statistics
  - Comparisons between children and parents
  - Within- and between-subject variability
  - Changes over time
- 1-NP metabolite levels in relation to:
  - Income
  - Race/ethnicity
- 1-NP levels in indoor air and dust
- Preview of GIS analyses

EBDEP Parents: Demographic Information

Gender (%)	
Female adults	95
Male adults	5
Blank cell Blank cell	Blank cell
Ethnicity (%)*	
African American	20
Hispanic/Latino	40
Caucasian	35
Asian	5
American Indian/Alaskan Native/Other Pacific Islander	5
Prefer not to identify	3
Age, mean (SD)	36.2 (8.1)

N=40 parents

*Some individuals selected more than one ethnicity

EBDEP Parents: Education and Income

Education (%)	
High school diploma, GED, technical school	20
Some college	20
College/graduate degree	60
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Income (%)	
$0 – 25,000	20
$25,000 – 75,000	40
> $75,000	38
Prefer not to answer/don't know	5

N=40 parents

EBDEP Children: Demographic Information

Gender (%)	
Female children	53
Male children	48
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Ethnicity (%)*	
African American	23
Hispanic/Latino	45
Caucasian	40
Asian	8
American Indian/Alaskan Native/Other Pacific Islander	5
Prefer not to identify	10
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Age (%)	
2 – 5 years	83
6 – 10 years	17
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Age, mean (SD)	4.6 (2.1) years

N=40 children

*Some individuals selected more than one ethnicity.

Selected Exposure Characteristics

blank	(%)
Parent work location	
At home	45
Outside the home	55
blank cell	Blank cell
Parent works with/around diesel	
Yes	28
No	72
Blank cell	Blank cell
Child daytime location (Mon – Fri)	
Home	33
School/Childcare	67
blank cell	Blank cell
Smoking at home	
Yes	3
No	97

N = 40 parent-child pairs

Results for 1-NP Metabolites in Urine

- Reported in picograms/liter (pg/L) and adjusted for specific gravity
  - Reference value of 1.017 (NHANES 2007-2008) chosen to be consistent with CARE-LA
- Method detection limits (MDLs)
  - 6-OHNP - 16 pg/L
  - 8-OHNP - 21 pg/L
- For purposes of initial statistical analyses presented here:
  - Results for 6-OHNP and 8-OHNP were averaged for each participant across both time points

1-NP Urinary Metabolite Concentrations

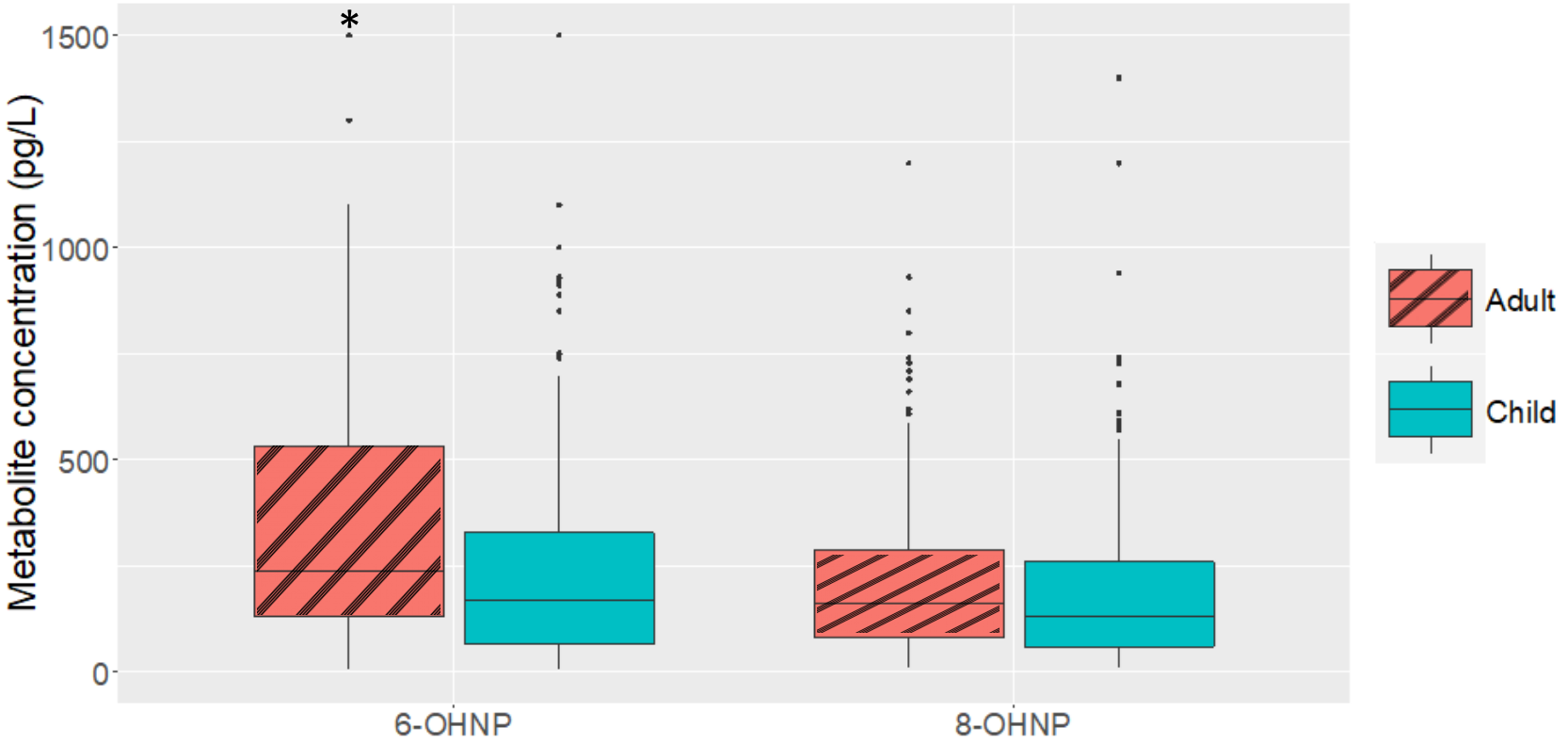
	Metabolite	n	DF (%)	GM	Median (IQR)	95th percentile
Adult	6-OHNP	138	98	250	240 (130 - 530)	1500
	8-OHNP	150	95	160	160 (83 - 290)	730
Child	6-OHNP	155	94	150	170 (64 - 330)	1000
	8-OHNP	168	95	130	130 (61 - 260)	740

n: number of samples

Results reported in pg/L, specific gravity adjusted

DF: detection frequency
GM: geometric mean
IQR: interquartile range (25^{th} –75^{th} percentile)

1-NP Metabolite Levels are Higher in Adults than Children



*T-test p-value<0.05

12 outliers above 1500 pg/L were excluded from boxplot for scale

Urinary 1-NP Metabolites Correlation Matrix

			Child		Adult	
		6-OHNP	8-OHNP	6-OHNP	8-OHNP
Child	6-OHNP	1	**0.90**** (n=130)	**0.16*** (n=116)	**0.14** (n=125)
	8-OHNP		1	**0.15*** (n=126)	**0.22** (n=137)
Adult	6-OHNP			1	**0.72**** (n=148)
	8-OHNP				1

**Pearson r p-value<0.05

Units: pg/L
n: number of samples (shown in parentheses)

1-NP Metabolite Within- and Between-Subject Variability

	6-OHNP			8-OHNP		
	Variance	% of Variance	ICC	Variance	% of Variance	ICC
Child						
Between	0.12	37%	0.37	0.07	33%	0.33
Within	0.19	63%		0.14	67%	
Adult						
Between	0.11	40%	0.40	0.09	42%	0.42
Within	0.16	60%		0.12	58%	

- Interclass correlation (ICC): measure of reliability that reflects degree of correlation and agreement between each subject's measurements

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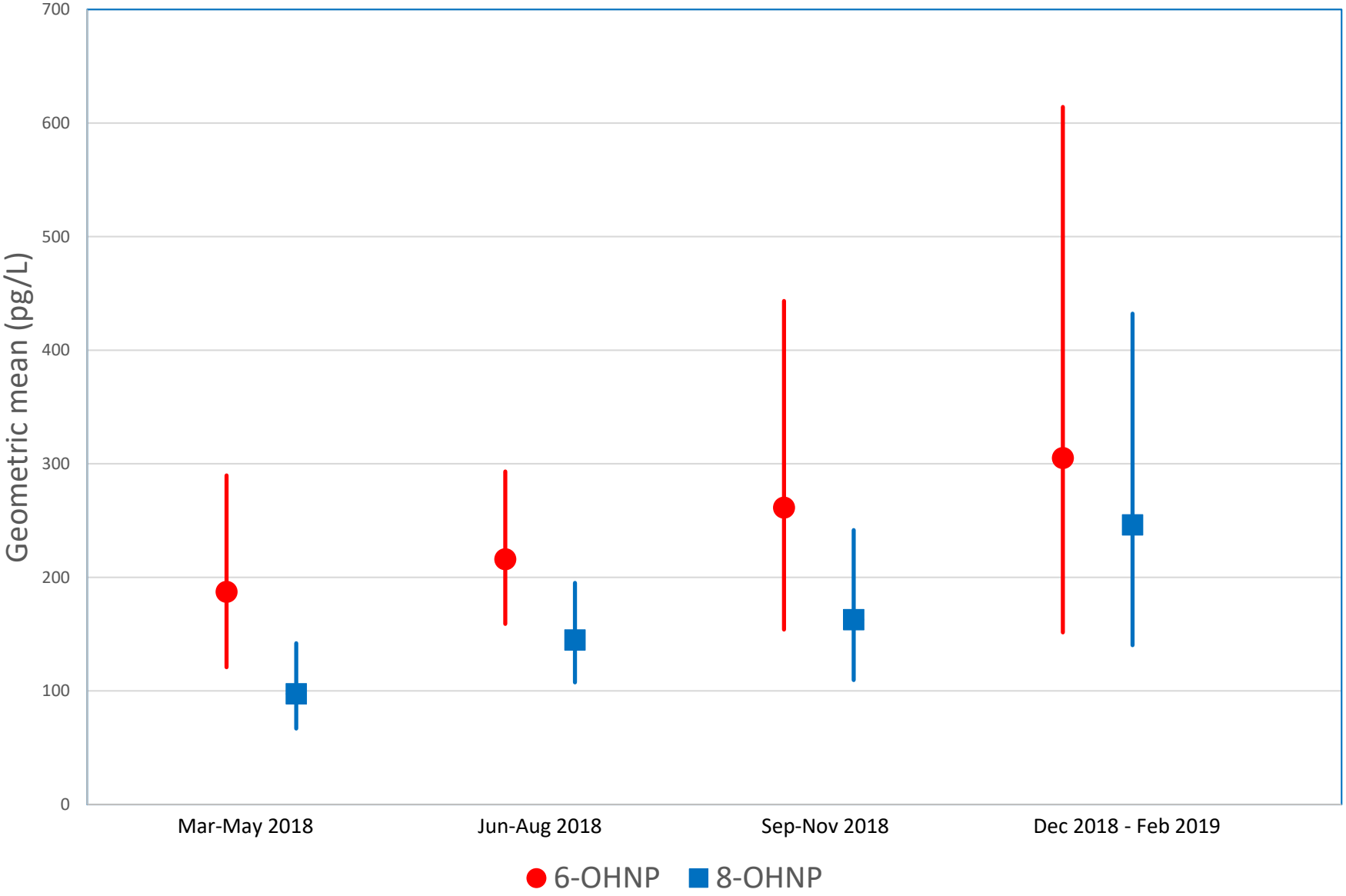
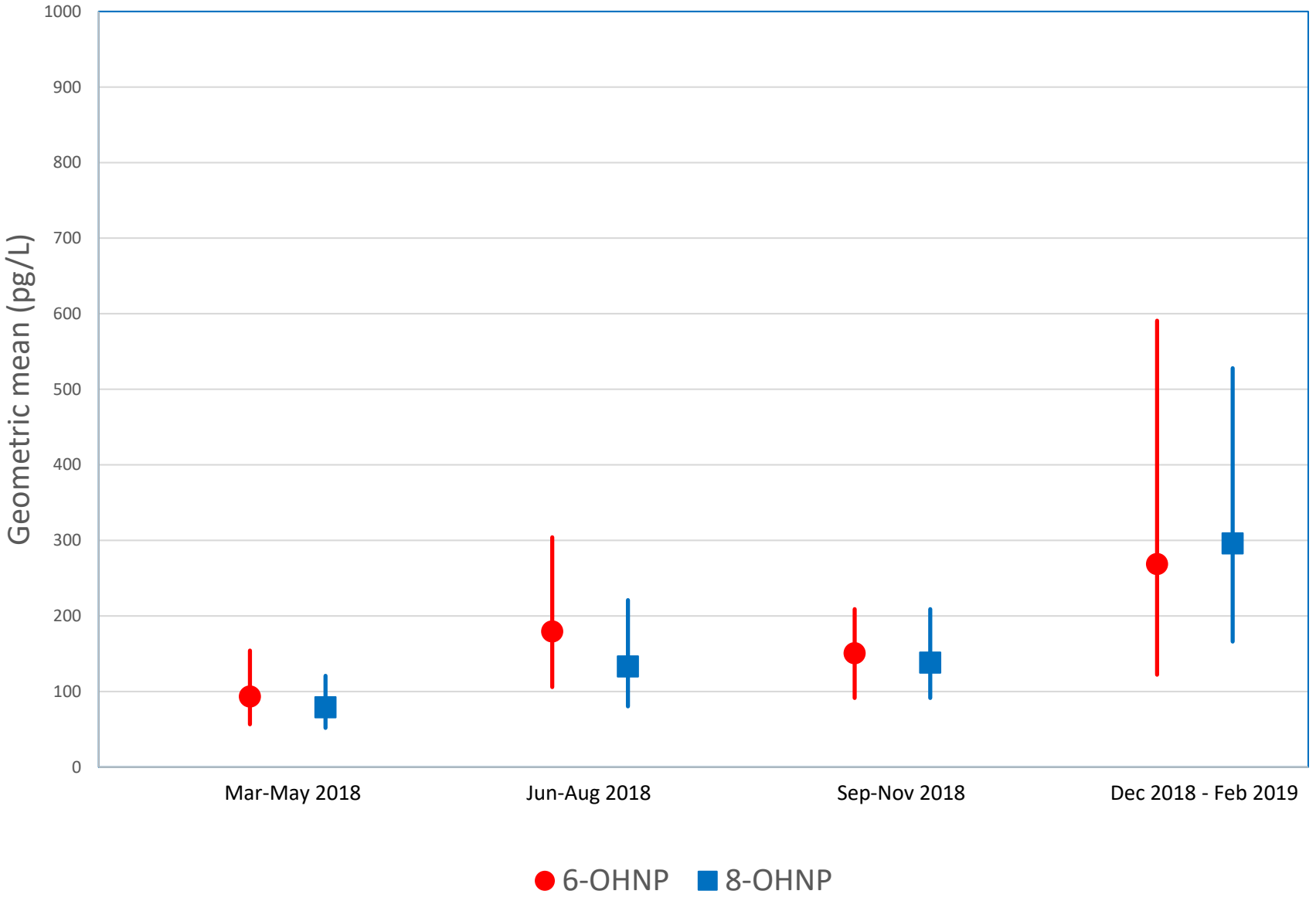
➢ **Within-subject variability is > between-subject variability**

1-NP Metabolites in Adults Over Time



1-NP Metabolites in Children Over Time



1-NP Metabolite Levels in Relation to Demographics of Parents

	GM (95% Confidence Interval)	
	6-OHNP	8-OHNP
Ethnicity of parent		
African American	290 (110, 790)	230 (81, 640)
Hispanic/Latino	270 (180, 400)	140 (100, 180)
Caucasian	330 (190, 580)	190 (120, 280)
Other†	220 (40, 1200)	170 (31, 940)
Family income		
<$25,000	160 (74, 330)	110 (58, 190)
$25,000-$75,000	270 (190, 400)	150 (110, 210)
>$75,000	420* (270, 650)	230* (150, 360)

†Category includes Asian, American Indian/Alaskan Native/Other Pacific Islander, and individuals who selected more than one ethnicity. Individuals who preferred not to identify ethnicity were not included in this analysis.

Units: pg/L
N=40 parents

*ANOVA p-value<0.05

1-NP Metabolite Levels in Relation to Demographics of Children

	GM (95% Confidence Interval)	
	6-OHNP	8-OHNP
Ethnicity of child		
African American	180 (66, 490)	170 (80, 350)
Hispanic/Latino	190 (130, 300)	160 (100, 230)
Caucasian	180 (75, 430)	160 (69, 380)
Other†	220 (130, 360)	190 (100, 340)
Family income		
<$25,000	180 (110, 300)	130 (68, 260)
$25,000-$75,000	230 (170, 310)	200 (150, 270)
>$75,000	200 (95, 410)	180 (89, 360)

†See previous slide for details.

Units: pg/L
N=40 children

1-NP Levels in Indoor Air and Dust

Media	n samples	DF (%)	GM	Median (IQR)	95th percentile
Air (pg/m^3)	78	77	0.43	0.43 (0.33-0.54)	0.86
Dust (pg/g)	37	97	370	340 (180 - 620)	2,700

MDLs
Air: 0.16 pg/filter (~ 0.3 pg/m^3)
Dust: 15 pg/g

- Air and dust levels are moderately correlated (Pearson r=0.46; p-value<0.01)

GIS Source Layers

On-road sources

- Highway Performance Monitoring System (HPMS)
  - AADT: Annual average daily traffic
  - HPMS road segments
- Bus routes and stops (AC Transit and Amtrak)
- Caltrans Truck Network
- Railway road crossings
- Major roads (primary highways, secondary roads)
- Caltrans Bottlenecks (tracks highway congestion)

Non-road sources

- Railway lines
- Industrial land use zoning maps (county)
- Ports
- Permitted stationary emission sources (BAAQMD), including gas stations, auto repair/body shops, industrial facilities

Maps of Potential Diesel Sources

SF and East Bay

West Oakland

LEGEND

Highway — HPMS road segment — Railway line — BAAQMD permitted emission source

Example Map of EBDEP GPS Logger Data*

*Example rendering not based on actual data

Traffic Volume near Participant's Residence, Work, and School/Childcare

- Daily counts (2017) from U.S. Highway Performance Monitoring System (HPMS)
- Compute daily vehicle-kilometers-traveled (VKT) near home within:
  - 500 meters
  - 1000 meters
  - 2000 meters
- For:
  - All vehicles
  - Buses and commercial trucks
  - Tractor-trailers (e.g., 18-wheelers)

Traffic Volume by Buffer Zone

Vehicle kilometers traveled per day (VKT)* within 500, 1000, and 2000 meter buffer zones around participants' homes

	Median	25th %	75th %
500 m			
All vehicles	43,934	29,677	178,127
Buses/commercial trucks	910	434	3,609
Tractor-trailer	465	197	3,784
1000 m			
All vehicles	290,012	132,693	469,998
Buses/commercial trucks	7,316	1,693	10,330
Tractor-trailer	6,189	960	10,752
2000 m			
All vehicles	1,212,973	877,307	1,434,472
Buses/commercial trucks	26,874	20,471	34,022
Tractor-trailer	24,576	19,136	31,815

*VKT are based on traffic counts by road segment lengths

GIS Analysis Plan

- Within each buffer area:
  - Quantify traffic volumes
  - Identify rail and maritime sources
  - Identify stationary sources

➢ **Examine associations between diesel sources and EBDEP results (urinary 1-NP metabolite levels; 1-NP levels in indoor air and dust)**

Innovative Aspects of EBDEP as a Biomonitoring California Study

- Measured urinary 1-NP metabolites in children
- Collected samples at two time points for all participants
  - Provides data to examine time trends within families
- Collected daily samples from some participants to examine within- and between-subject variability
- Collected complementary environmental samples
  - Developed methods to measure 1-NP in air filters and dust

Next Steps for Data Analyses

- Examine predictors of diesel exhaust exposure
  - Work-related exposures
  - Traffic volume and other sources near home, work, school or childcare
  - Rail and maritime sources
  - Indoor indicators of diesel exhaust (e.g., 1-NP in air and dust)

{Will also evaluate household combustion sources as potential confounder}

- Account for time-activity patterns
  - Time spent in transit and at fixed locations
- Evaluate other factors that can impact diesel exhaust exposures, including:
  - Ambient air quality (e.g., $PM_{2.5}$, NO_2)
  - Meteorological information (e.g., rain)

EBDEP provides a rich dataset to better understand diesel exhaust exposures and inform exposure reduction

We would like to thank all the participating families for their valuable time and effort!

Questions and Discussion