

Trends of Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) and Persistent Organic Pollutants (POPs) in Pregnant Californians

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Surveillance Feasibility

- Aim of surveillance is to determine population-level estimates
 - Temporal trends
 - Geographic differences
 - Demographic subgroups
- Feasibility of using prenatal samples from Genetic Disease Screening Program

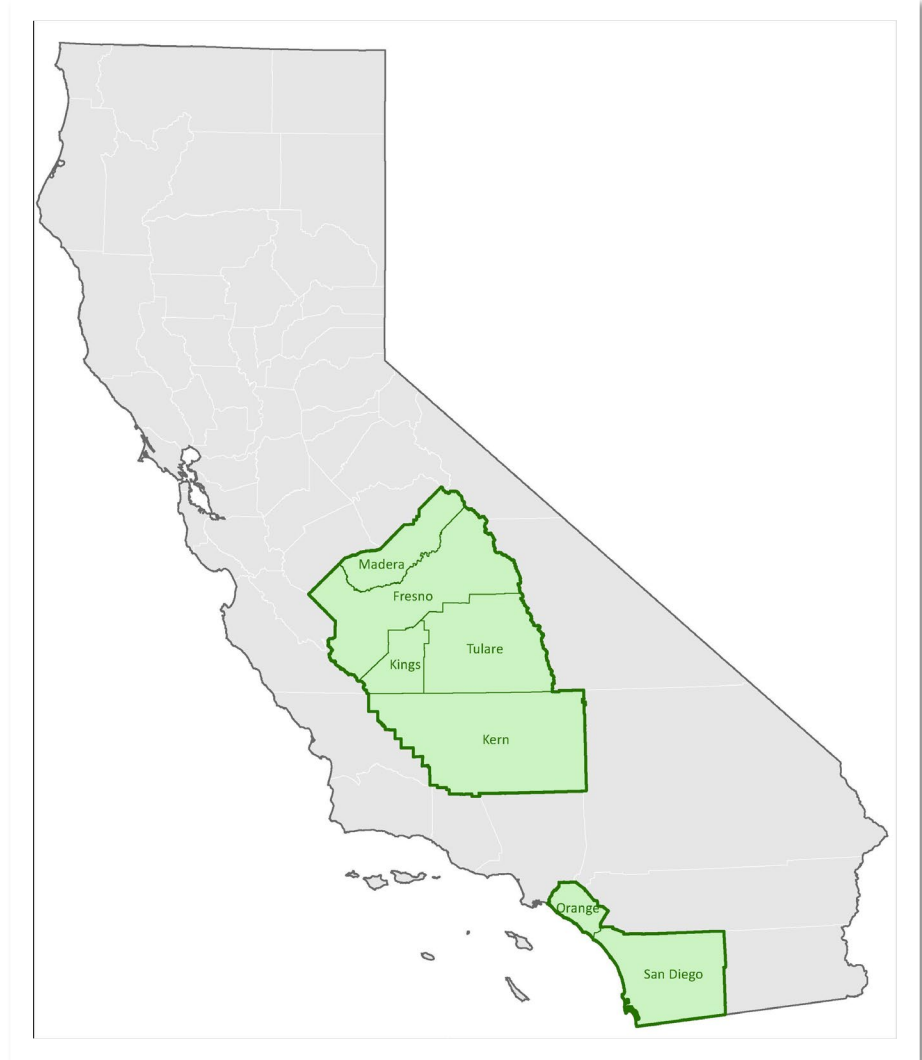


GDSP: Prenatal Screening Program

- Offered by prenatal care providers to all pregnant individuals in California
- Blood samples are drawn to screen for certain birth defects
- Second trimester samples are collected between 15 weeks 0 days and 20 weeks 0 days gestational age
- About 70% of pregnant Californians participate in prenatal screening
- Standardization of sample collection methods across the state

California Biobank Program

- GDSP archives prenatal samples from Fresno, Kern, Kings, Madera, Tulare, Orange, and San Diego counties
- Non-Biobank samples are typically discarded after one month, but can be saved upon request



Measuring Analytes in Maternal Archived Samples (MAMAS)



Study Design

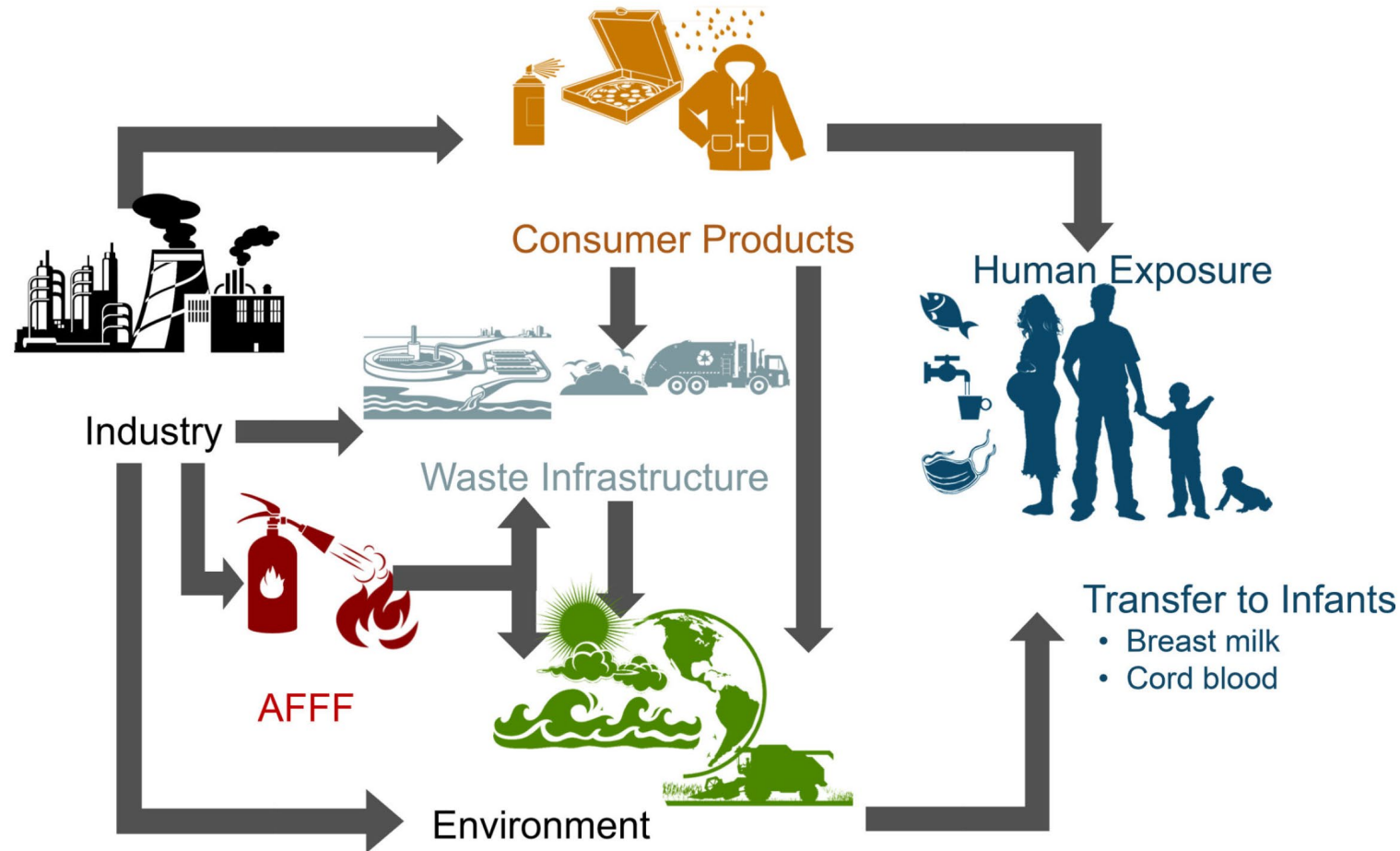
	Sample Collection	Sampling Timeframe	Sampling Method
MAMAS 1	Archived	2012 (12-months)	Race-stratified random sampling: <ul style="list-style-type: none">• Equal number of Asian (limited to Chinese, Filipina, Vietnamese), Black, Hispanic, and White participants
MAMAS 2	Prospective	September 2015 - April 2016	Region-stratified sampling with quota-based sampling by race/ethnicity: <ul style="list-style-type: none">• Equal number of Asian (limited to Chinese, Filipina, Vietnamese), Black, Hispanic, and White participants
MAMAS 3	Prospective	July 2016 - January 2017	Region-stratified sampling with quota-based sampling by race/ethnicity: <ul style="list-style-type: none">• Equal number of Asian (limited to Chinese, Filipina, Vietnamese), Black, Hispanic, and White participants

Subsamples for Analysis

	# of Samples	Collection Dates	Geography	Subsamples for Analysis
MAMAS 1	460	2012	San Diego/Orange Counties	PFASs (n=200) POPs (n=58)
MAMAS 2	540	2015-2016	Northern Counties Alameda/Contra Costa Los Angeles County Riverside/San Bernardino	PFASs (n=292) POPs (n=245)
MAMAS 3	300	2016-2017	North Bay San Francisco/Central Coast Southern Counties	PFASs (n=96) POPs (n=204)

Perfluoroalkyl and polyfluoroalkyl substances (PFASs)
Persistent Organic Pollutants (POPs)

Perfluoroalkyl and polyfluoroalkyl substances PFASs



Sunderland, E.M., Hu, X.C., Dassuncao, C. *et al.* A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects. *J Expo Sci Environ Epidemiol* **29**, 131–147 (2019).

Questions

- Does PFAS exposure vary by demographic characteristics?
- What are the trends in California residents' exposures to PFASs?

Demographics Characteristics of PFAS Subsample

	MAMAS 1 2012		MAMAS 2 2015-2016		MAMAS 3 2016-2017	
	N	%	N	%	N	%
Race/ethnicity						
White	50	25	76	26	24	25
Black	50	25	66	23	24	25
Hispanic	50	25	65	22	24	25
Chinese	17	9	33	11	9	9
Filipina	15	8	30	10	8	8
Vietnamese	18	9	22	8	7	7

Demographics Characteristics of PFAS Subsample

	MAMAS 1 2012		MAMAS 2 2015-2016		MAMAS 3 2016-2017	
	N	%	N	%	N	%
Medi-Cal						
Yes	59	30	83	28.4	28	29.2
No	141	71	209	71.6	68	70.8
Age, years						
<15	0	0	1	0	0	0
15-19	7	4	11	4	5	5
20-24	29	15	46	16	15	16
25-29	56	28	76	26	17	18
30-34	68	34	102	35	35	37
35-39	31	16	45	15	19	20
40-44	8	4	10	3	5	5
≥45	1	1	1	0	0	0

PFAS Detection Frequencies in MAMAS 1-3

- Of the 11 PFASs measured in MAMAS 1, seven PFASs were measured in > 65% samples
 - PFOS, PFOA, PFHxS, PFNA, PFDA, PFUnDA, Me-PFOSA-AcOH
- Of those 11 PFASs, in MAMAS 2 and MAMAS 3, six PFASs were measured in > 65% samples
 - PFOS, PFOA, PFHxS, PFNA, PFDA, PFUnDA
- Highlighted PFASs detected in all samples
- Subsequent slides will focus on the six PFASs detected in > 65% MAMAS 1-3 samples

PFAS Levels by Age and Medi-Cal Insurance

- No association between age and PFAS levels
- Medi-Cal insurance and PFAS levels
 - In MAMAS 1
 - Lower PFAS levels among those with Medi-Cal insurance for all PFASs
 - In MAMAS 2 & MAMAS 3
 - No association between Medi-Cal and PFOS, PFOA, and PFHxS, respectively
 - Lower levels among those with Medi-Cal for all other PFASs

PFAS Levels by Race/Ethnicity

	Chinese	Filipina	Vietnamese	Black	Hispanic	White	
PFOS	↑		↑↑	↓	↓↓		MAMAS 1
	↑		↑↑	↓	↓↓		MAMAS 2/3
PFOA				↓↓	↓↓	↑↑	MAMAS 1
	↑↑		↑↑	↓↓	↓↓	↑↑	MAMAS 2/3
PFHxS	↓↓			↓	↓	↑↑	MAMAS 1
	↓↓				↓↓	↑↑	MAMAS 2/3
PFNA			↑↑	↓	↓		MAMAS 1
	↑		↑↑	↓↓	↓↓		MAMAS 2/3
PFDA	↑	↑	↑↑		↓↓		MAMAS 1
	↑	↑	↑↑	↓	↓		MAMAS 2/3
PFUnDA	↑	↑	↑↑	↓	↓		MAMAS 1
	↑	↑	↑↑		↓		MAMAS 2/3

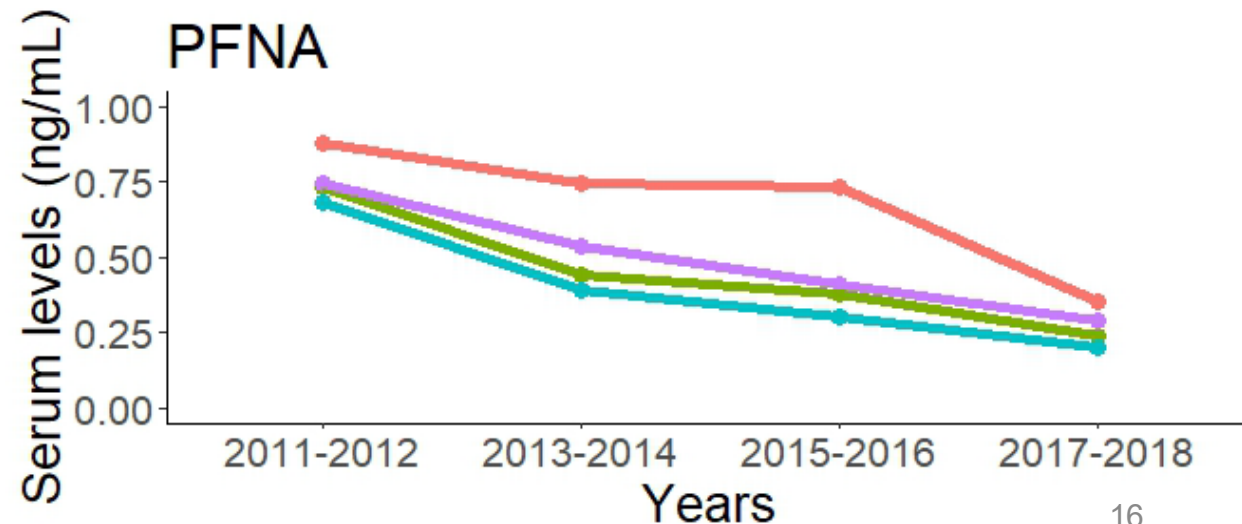
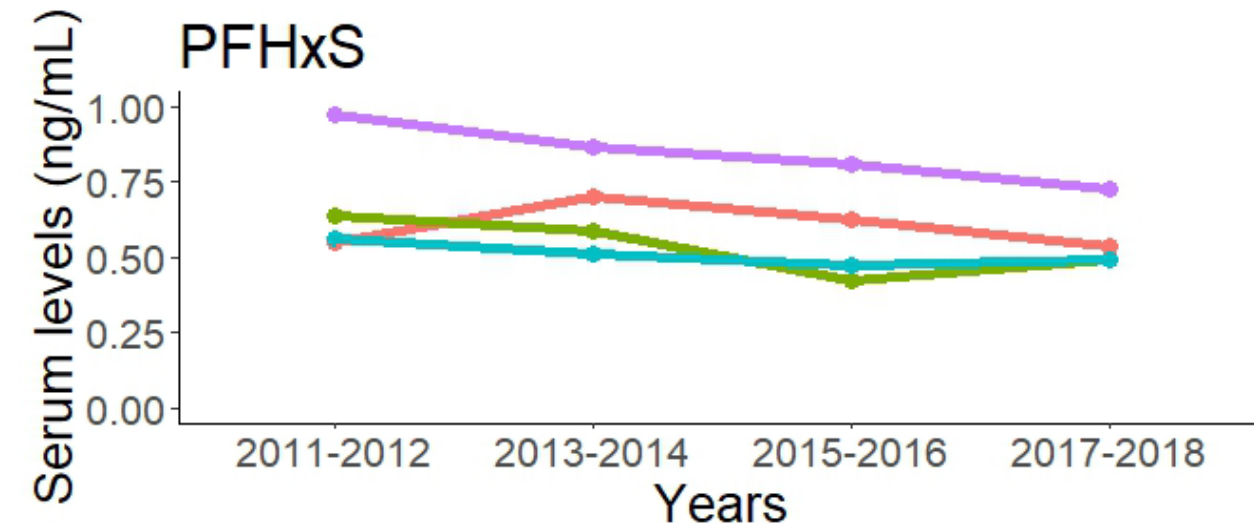
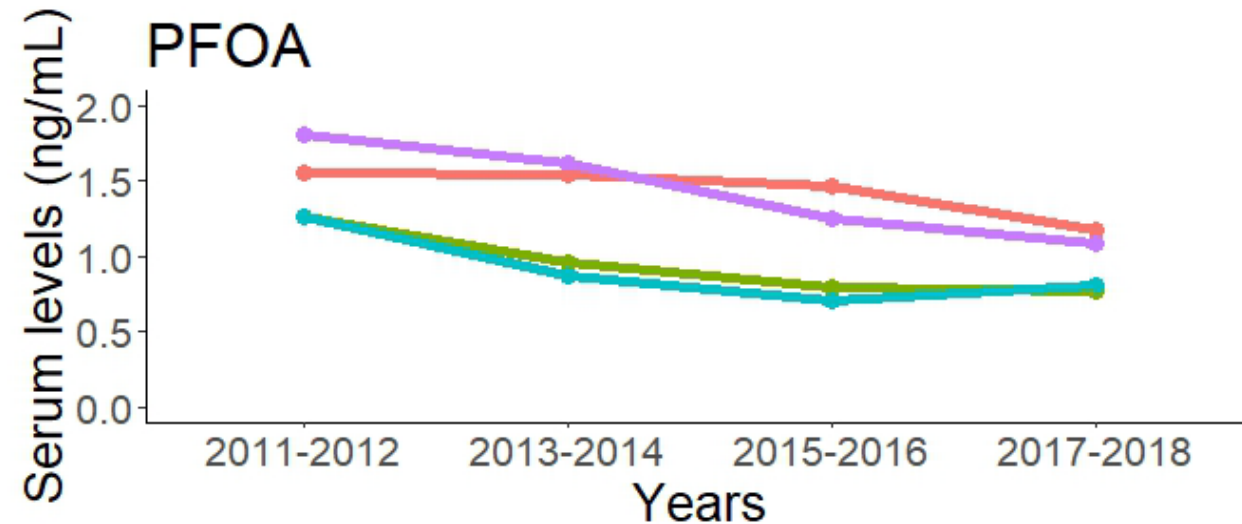
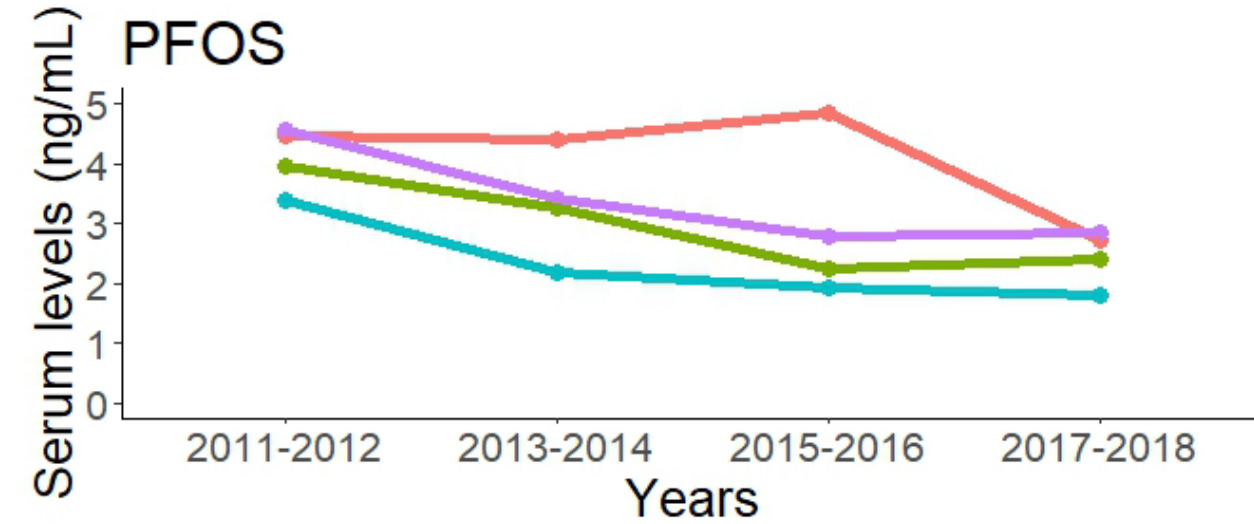
Legend ↑↑ highest geometric mean and significantly different from other race/ethnic groups ↑ higher geometric mean (not statistically significant) 14
 ↓↓ lowest geometric mean and significantly different from other race/ethnic groups ↓ lower geometric mean (not statistically significant)

Summary of PFAS Levels by Race/Ethnicity

- Hispanic participants had lower exposures across PFAS analytes
- For each PFAS, different relative levels by race/ethnicity
- Collapsing Asian ethnicities to an overall Asian category masks highly exposed Vietnamese participants

National Trends in PFAS Levels

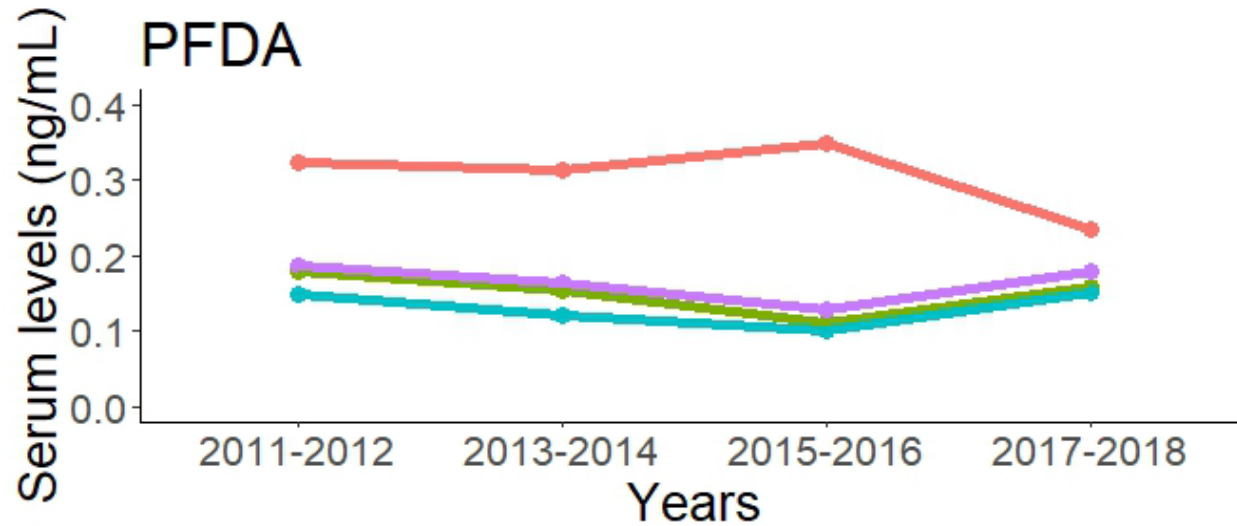
Race Asian Black Mexican American White



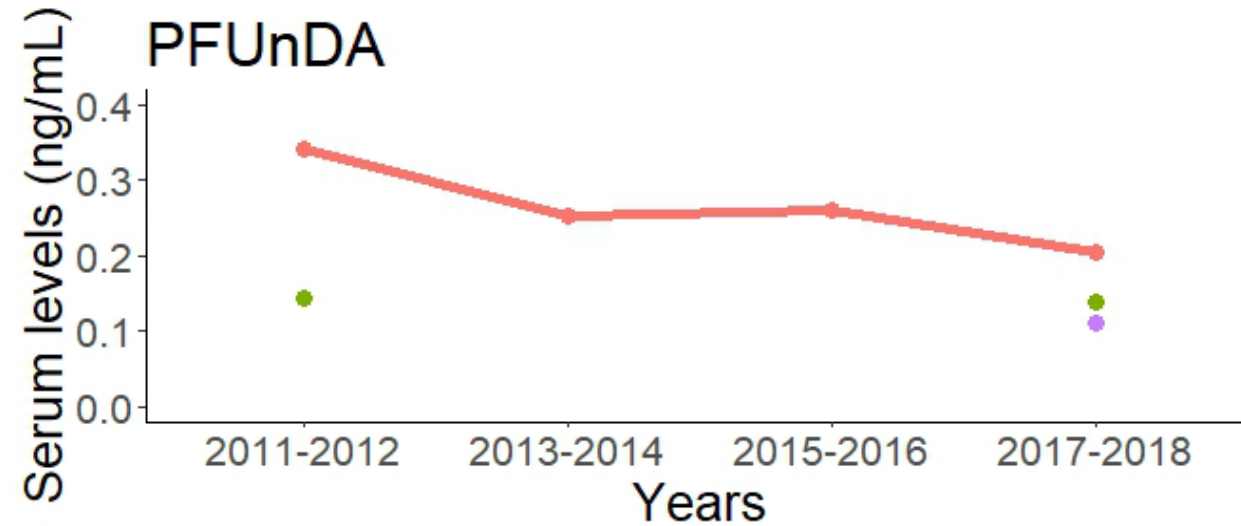
MAMAS PFAS Levels Compared to National Data

- PFOS: similar trend and relative level
- PFOA: similar trend and relative level for White, Hispanic, Black participants
 - Nationally, high levels among Whites and Asians. Asian participants had lower levels than White participants in MAMAS 1 and MAMAS 3.
- PFHxS: Higher levels in 2012 and then decreased at a faster rate
- PFNA: Similar levels in 2012 and then decreased at a slower rate

National Trends in PFDA and PFUnDA Levels



Race Asian Black Mexican American White



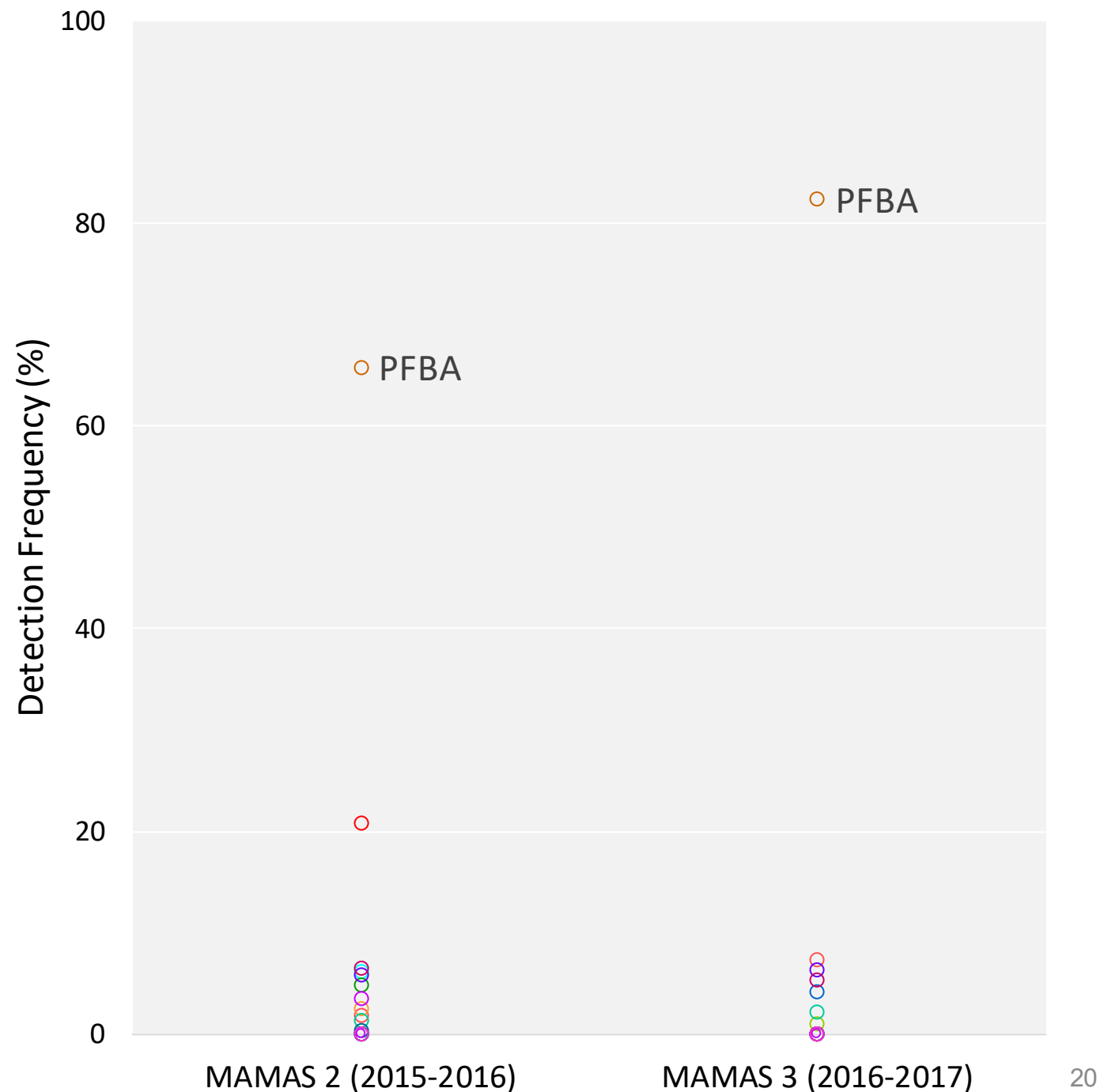
Race Asian Black Mexican American White

MAMAS PFDA and PFUnDA Levels Compared to National Data

- PFDA: similar trend and relative level
- PFUnDA: inconsistent with national data - steady levels across all race/ethnic groups

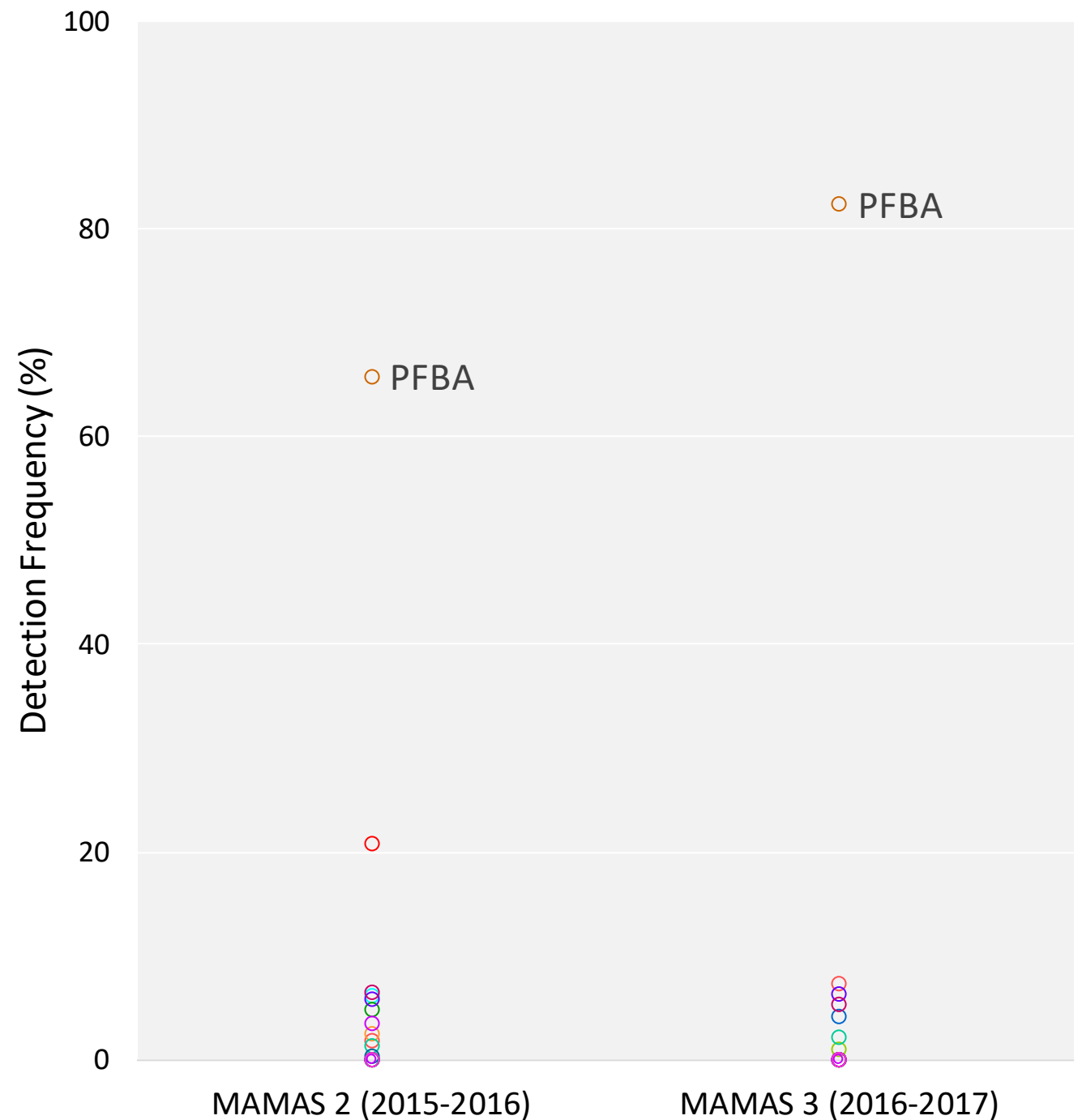
Detection Frequencies of Additional PFASs

- Lab measured an additional 18 PFASs in MAMAS 2 and 19 in MAMAS 3.
 - 12 detected in MAMAS 2
 - 7 detected in MAMAS 3
- One analyte method detection limit (MDL) differed between MAMAS 2 and MAMAS 3; highest MDL was applied to all samples for this comparison.
- MAMAS 2 and MAMAS 3 differ by sampling regions and time.



Detection Frequencies of Additional PFASs

- High detection frequency of PFBA in MAMAS 2 and MAMAS 3
- PFASs with low detection frequencies will be tracked in future studies



PFBA in MAMAS 2-3 Compared to Other Studies

Study/Citation	Years	Study population and location	N	% detect	MDL
Gockener et al.	2009-2019	German Environmental Specimen Bank	100	0%	0.25
Ingelido et al.	2015-2016	Italy, adults exposed to contaminated drinking water	257	7%	0.02
		Italy, adults not exposed	250	17%	0.02
MDH	2008	East Metro PFC Biomonitoring Pilot Project	196	25%	0.01
SHOW	2014-2016	Wisconsin adults, subset of statewide representative	605	29%	0.039
ACE 1	2016	Chinese adults residing in SF Bay Area	96	63%	0.0500
MAMAS 2	2015-2016	Prenatal samples from various CA counties	292	66%	0.0500
ACE 2	2017	Vietnamese adults residing in SF Bay Area	99	68%	0.0500
MAMAS 3	2016-2017	Prenatal samples from various CA counties	96	82%	0.0500
Polachova et al.	2019	Czech city policemen, Spring	142	89%	0.01
		Same policemen, Autumn	132	88%	0.01

N total number of participants, MDL method detection limit, MDH Minnesota Department of Health, SHOW Survey of the Health of Wisconsin, ACE Asian/Pacific Islander Community Exposures Project

Persistent Organic Pollutants POPs

- Polychlorinated biphenyls (PCBs)
 - Products and building materials produced before 1980
- Polybrominated diphenyl ethers (PBDEs)
 - Foam in furniture, pillows, motor vehicle seats, and baby products manufactured before 2006
 - Casing of electronics, some mattresses and upholstery fabric manufactured before 2013
- Organochlorine pesticides (OCPs)
 - Agriculture and for home pest control
 - All OCPs measured are no longer used in the U.S.



Question

- Did California residents' exposure to specific POPs decrease across the MAMAS studies?

Demographics Characteristics of POPs Subsample

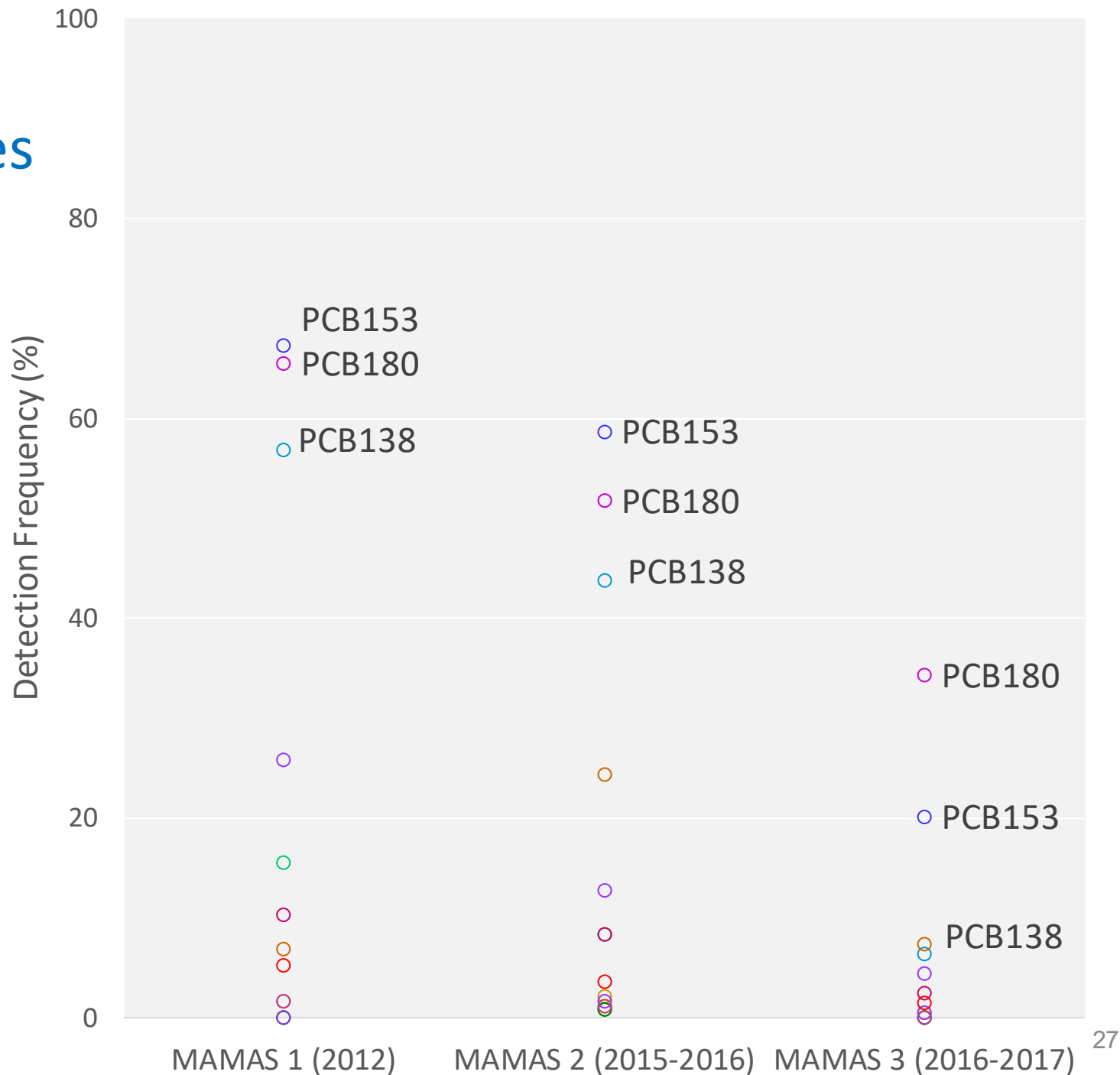
	MAMAS 1 2012		MAMAS 2 2015-2016		MAMAS 3 2016-2017	
	N	%	N	%	N	%
Race/ethnicity						
White	20	35	68	28	51	25
Black	20	35	52	21	51	25
Hispanic	18	31	71	29	51	25
Chinese	0	0	17	7	22	11
Filipina	0	0	26	11	19	9
Vietnamese	0	0	11	5	10	5

Demographics Characteristics of POPs Subsample

	MAMAS 1 2012		MAMAS 2 2015-2016		MAMAS 3 2016-2017	
	N	%	N	%	N	%
Medi-Cal						
Yes	22	38	70	29	66	32
No	36	62	175	71	138	68
Age, years						
<15	0	0	0	0	0	0
15-19	3	5	8	3	5	3
20-24	10	17	35	14	20	10
25-29	15	26	73	30	59	29
30-34	18	31	81	33	75	37
35-39	11	19	41	17	38	19
40-44	1	2	6	9	7	3
≥45	0	0	1	0	0	0

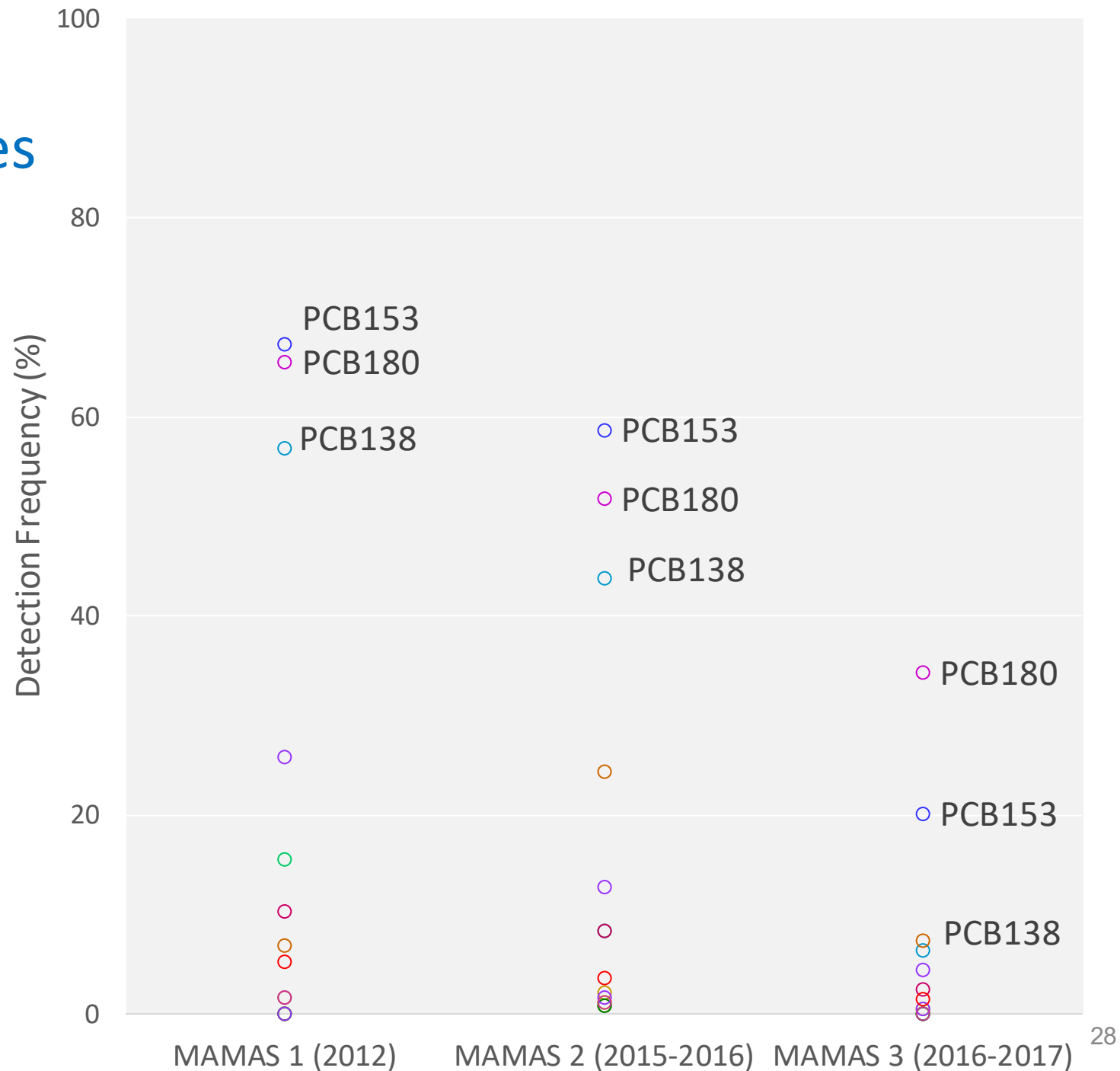
PCB Detection Frequencies

- 15 PCBs measured in MAMAS 1, MAMAS 2, and MAMA 3.
 - Some PCBs were not detected
- Since analyte method detection limits (MDLs) differed across studies, the highest MDL was applied to all samples for this comparison.



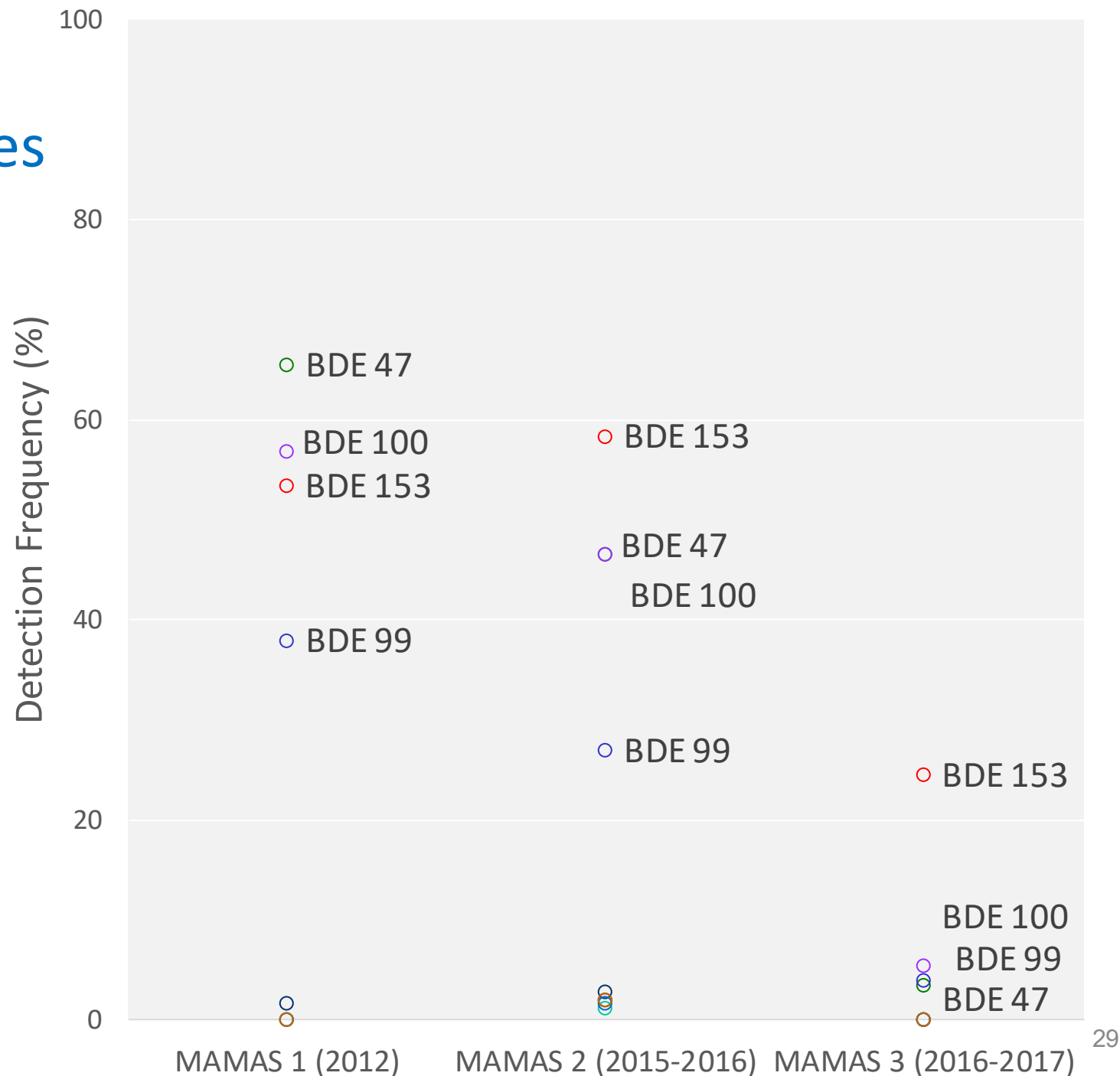
PCB Detection Frequencies

- MAMAS 1 - MAMAS 3 vary by demographics, time, and region.
- Decreasing detection frequency of PCB analytes with each study.



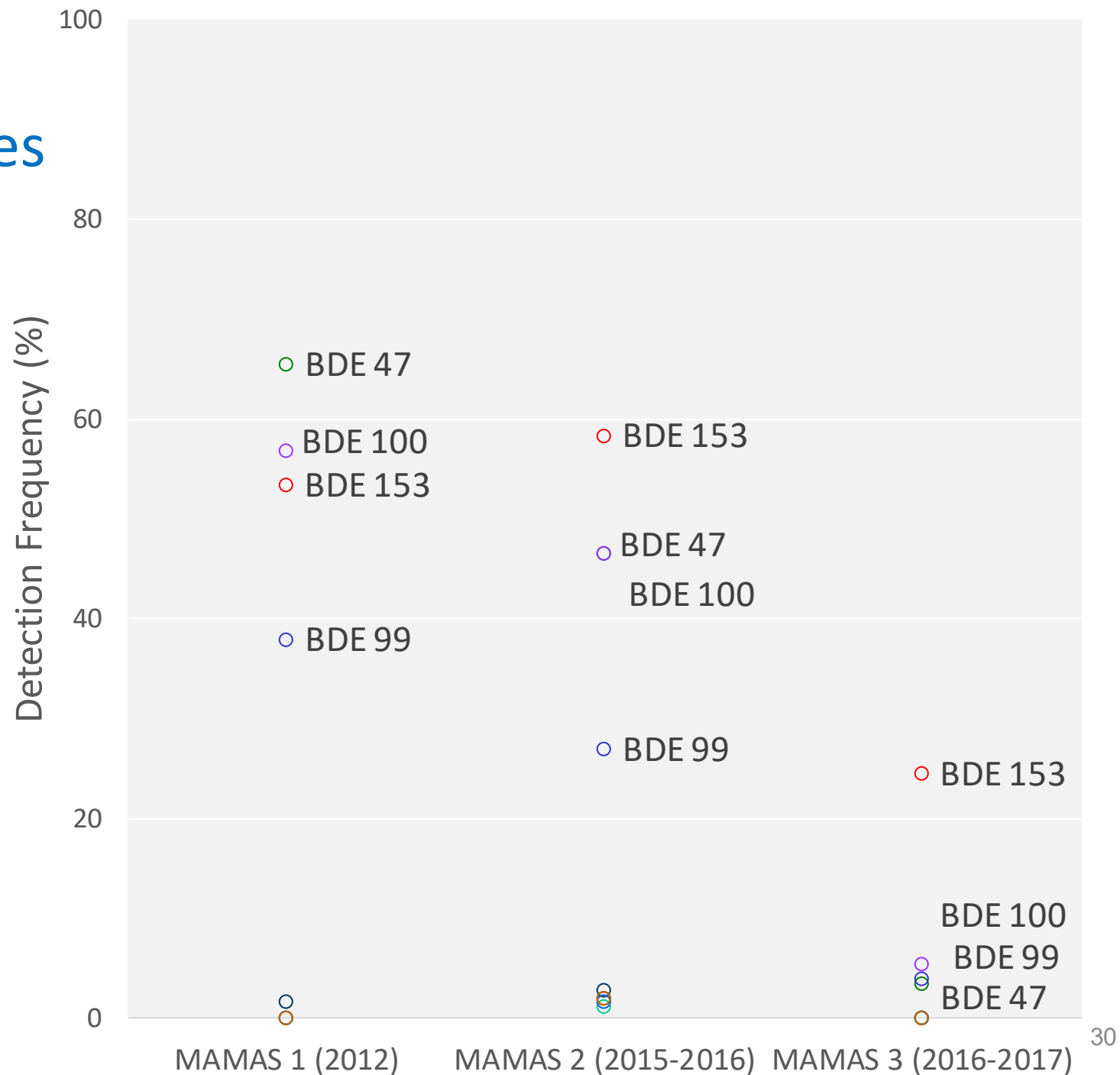
PBDE Detection Frequencies

- 9 PBDEs measured in MAMAS 1, MAMAS 2, and MAMA 3.
 - Some PBDEs were not detected
- Since analyte method detection limits (MDLs) differed across studies, the highest MDL was applied to all samples for this comparison.



PBDE Detection Frequencies

- MAMAS 1 - MAMAS 3 vary by demographics, time, and region.
- With each study, decreasing detection frequency for PBDEs.

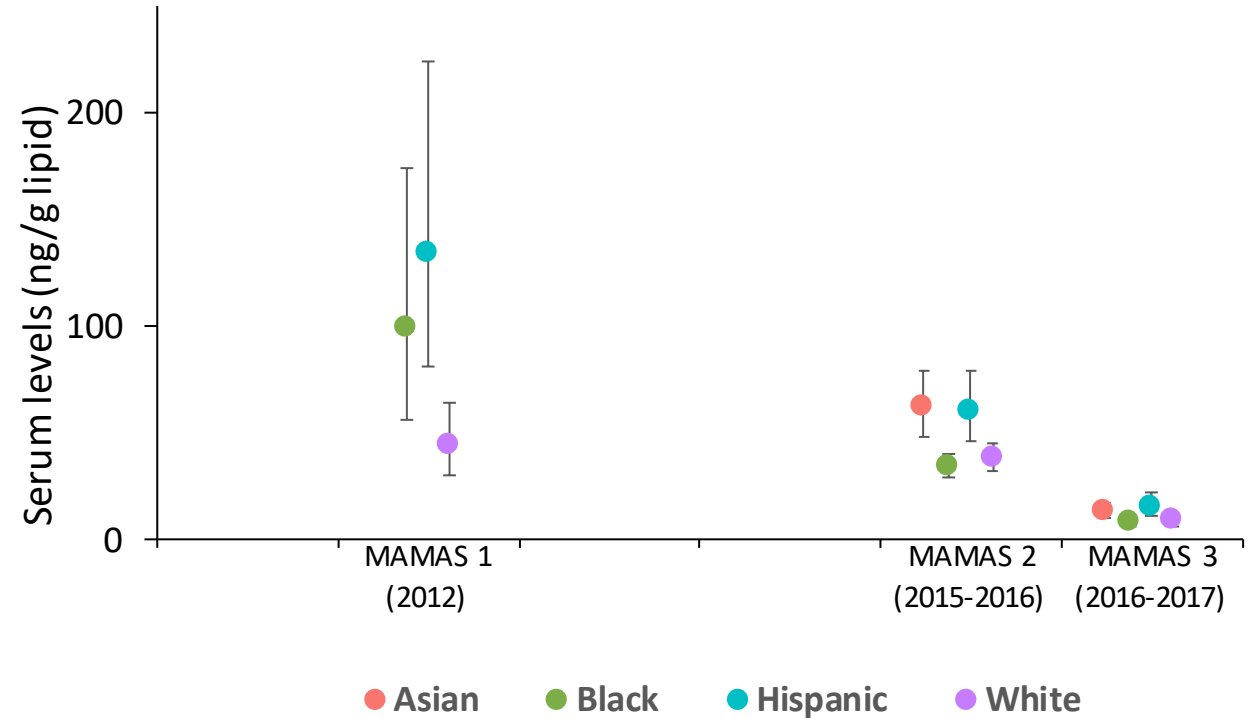


Organochlorine Pesticides Levels in MAMAS 1 -3

- Two organochlorine pesticides were detected in nearly all samples: every participant had measurable levels of p,p-DDE (metabolite of DDT) and/or HCB
- DDT
 - Banned from use in U.S. in 1972, with exceptions
 - Per ATSDR, last produced in the U.S. in the 1980s
 - DDT used abroad to control vector-borne diseases
- HCB
 - Use in U.S. discontinued in 1984
 - Chemical production by-product and still produced outside the U.S.

p,p-DDE Levels by Race/Ethnicity

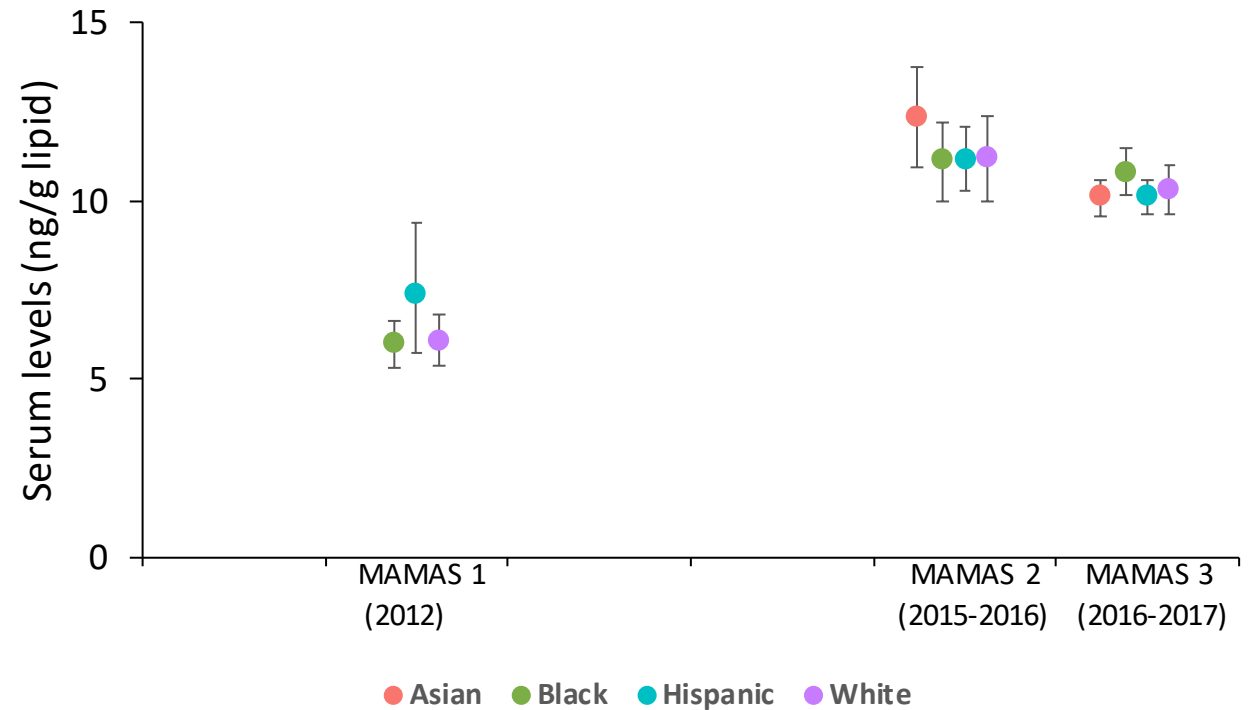
- p,p-DDE levels decreased for all race/ethnicity groups
 - Decreasing trend consistent with national data
- Higher exposures among Hispanic and Asian participants
 - Consistent with national data



Geometric means and 95% confidence intervals

HCB Levels by Race/Ethnicity

- HCB levels higher in MAMAS 2 and MAMAS 3 compared to MAMAS 1 for all race/ethnic groups
 - Inconsistent with steady levels in national data





NEXT STEPS

Looking Forward

- MAMAS confirmed feasibility of leveraging GDSP
 - Archived samples in California Biobank Program
 - Prospective sample collection from non-Biobank counties
- Aim of surveillance is to determine population-level estimates
 - Temporal trends
 - Geographic differences
 - Demographic subgroups

STEPS



Next Steps: MAMAS collaborations



- Understanding exposure sources
 - Geospatial mapping of PFAS exposure sources
- Additional environmental chemicals
 - Potential add-on analyses: short-chain PFASs, total PFAS method
- Exposure and health
 - Associations with birth outcomes
 - Potential add-on analyses: biomarkers of immune response



BIOMONITORING CALIFORNIA

MEASURING CHEMICALS IN CALIFORNIANS