Associations Between Per- and Polyfluoroalkyl substances (PFASs) in Drinking Water and Serum Among Southern California Adults: Initial Results

Biomonitoring California Scientific Guidance Panel Meeting
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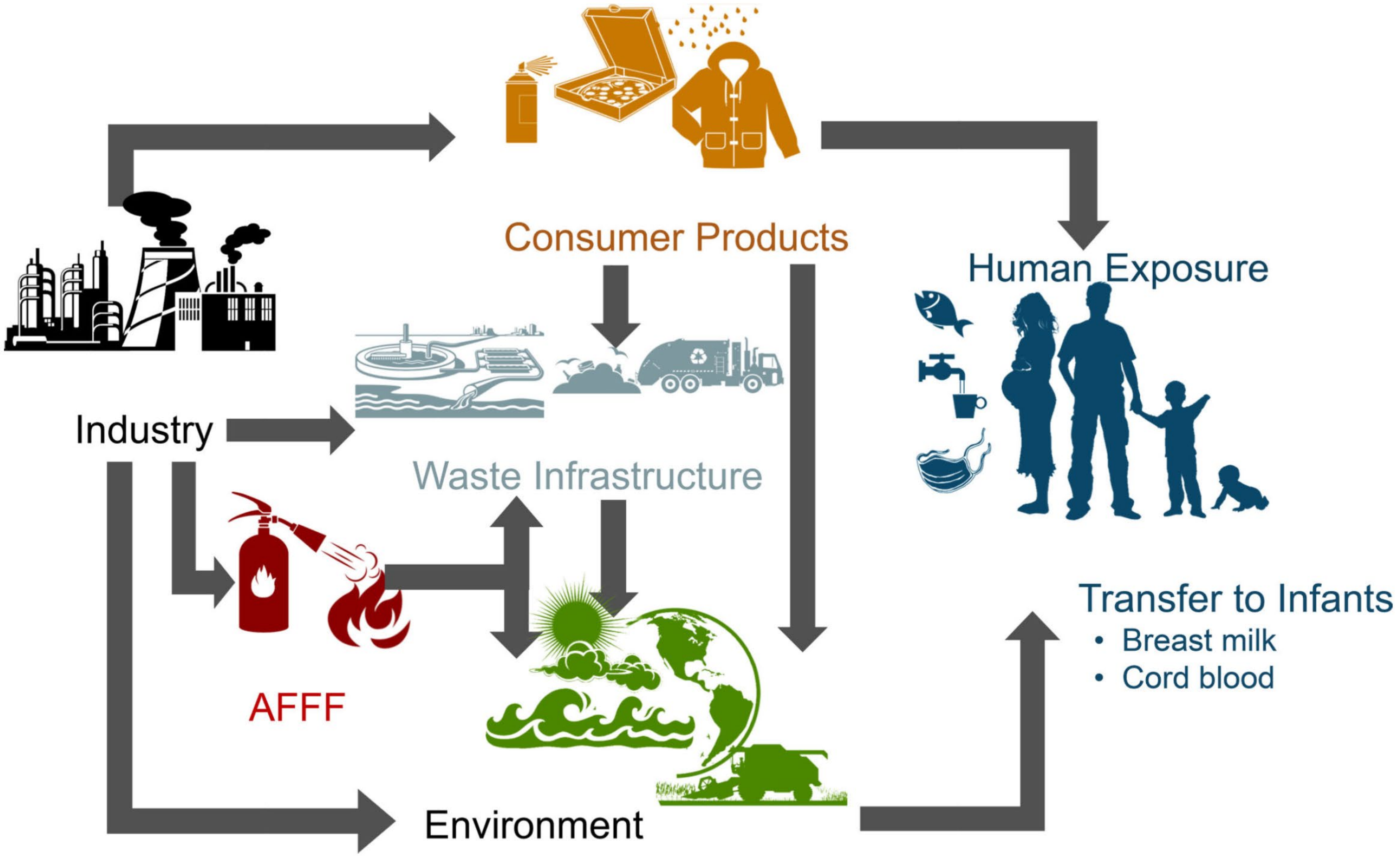
PFAS exposure pathways



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).

PFAS exposure pathways

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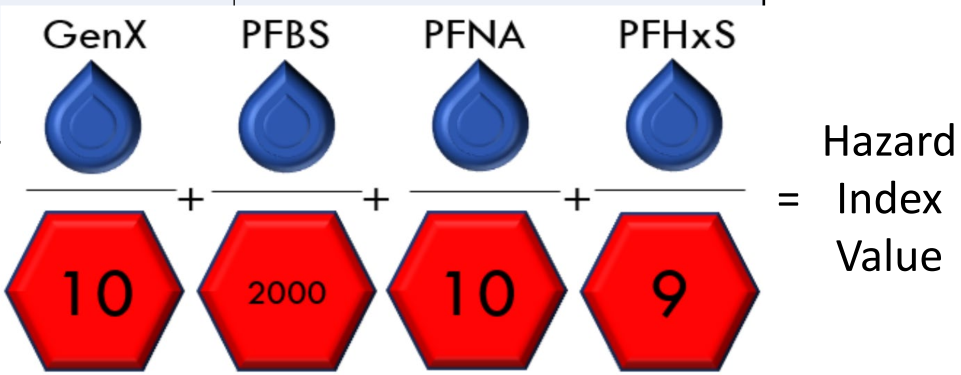
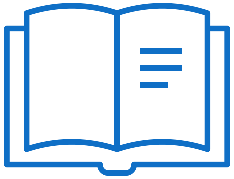
EPA's Proposed National Primary Drinking Water Regulation

Compound	Proposed MCLG	Proposed MCL (enforceable levels)
PFOA	0 ppt	4.0 ppt
PFOS	0 ppt	4.0 ppt
PFNA	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS		
PFBS		
HFPO-DA (commonly referred to as GenX Chemicals)		



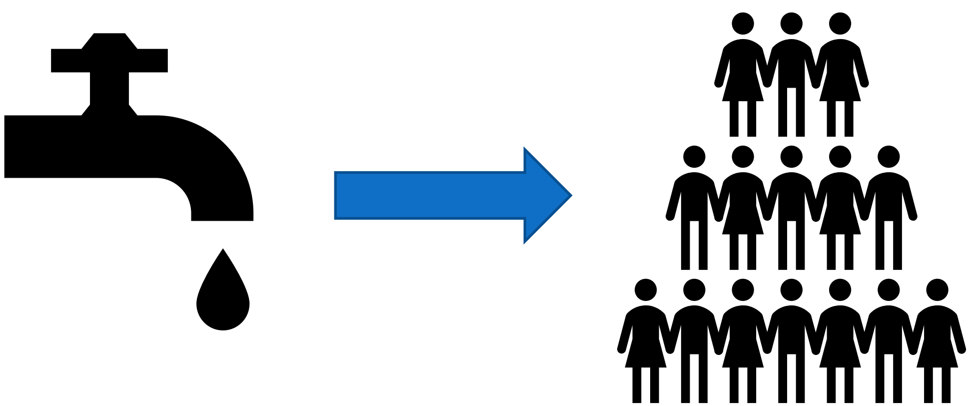
PFASs and drinking water in the literature

- Studies from areas with high PFAS contamination have reported significant contributions of drinking water to overall PFAS exposure
- Few studies have focused on the general population



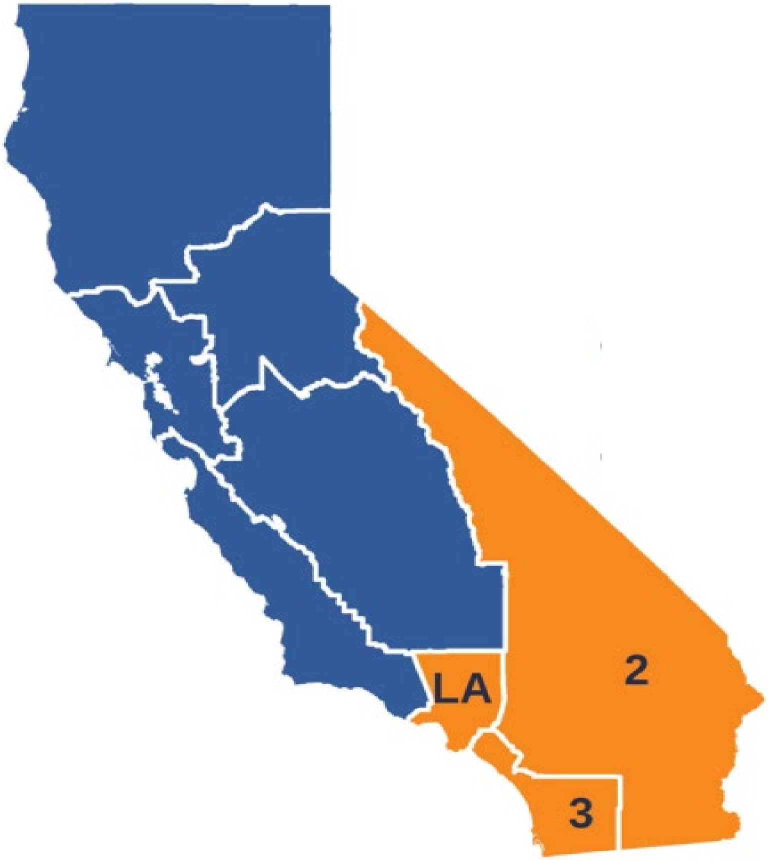
Study objective

- To estimate the contribution of PFAS detections in drinking water to the concentration of PFASs in serum among a general population of adults in California



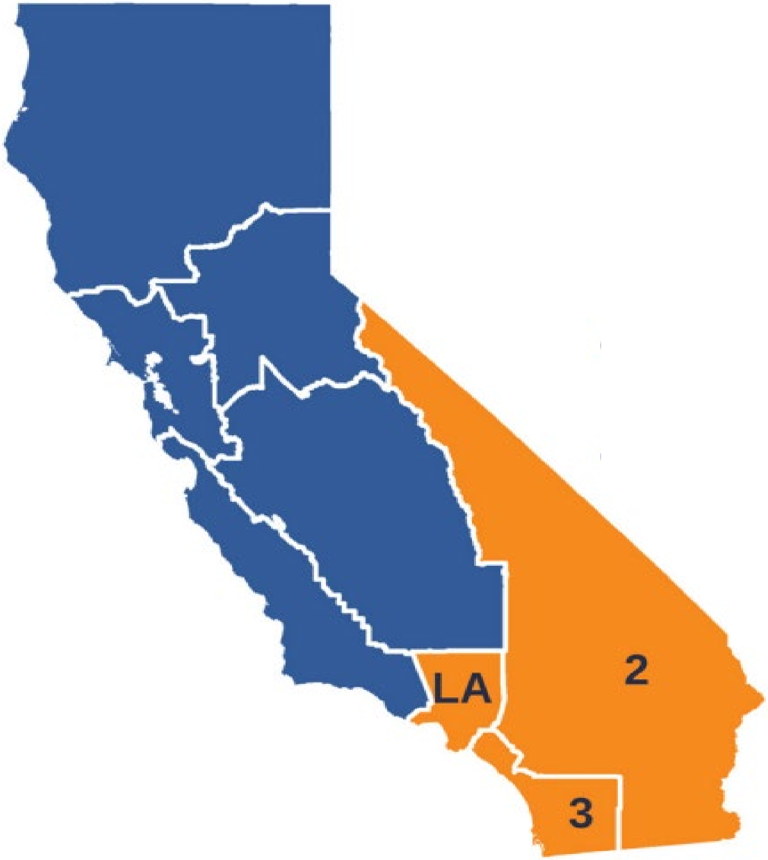
California Regional Exposure (CARE) Study

- Measured 12 PFASs in serum
- Exposure questionnaire
  - Demographics
  - Reproductive history
  - Diet
  - Home characteristics
  - Occupation
  - Hobbies



California Regional Exposure (CARE) Study

- CARE-LA (2018)
  - n = 430
- CARE-2 (2019)
  - n = 359
- CARE-3 (2020)
  - n = 90



PFAS testing in drinking water

California Water Board PFAS monitoring

- PFAS monitoring data from water systems included in first three investigative orders (2019 – 2022)
- Most sampling from source wells from areas with suspected PFAS contamination
- Statewide required reporting limits (2-4 ng/L) 10x lower than UCMR3

UCMR3
(EPA)
2013 - 2015

Apr 2019
Phase I: 248 public water systems

Aug 2020
Phase II: 224 public water systems

Feb 2021
Phase III: 150 public water systems

Matched CARE participants to public water systems

CARE-LA, 2, and 3 participants with blood samples — n = 872

↓

Address matched during geocoding in ArcGIS — n = 863

↓

Matched to a water system in the System Area Boundary Layer (SABL) — n = 846

↓

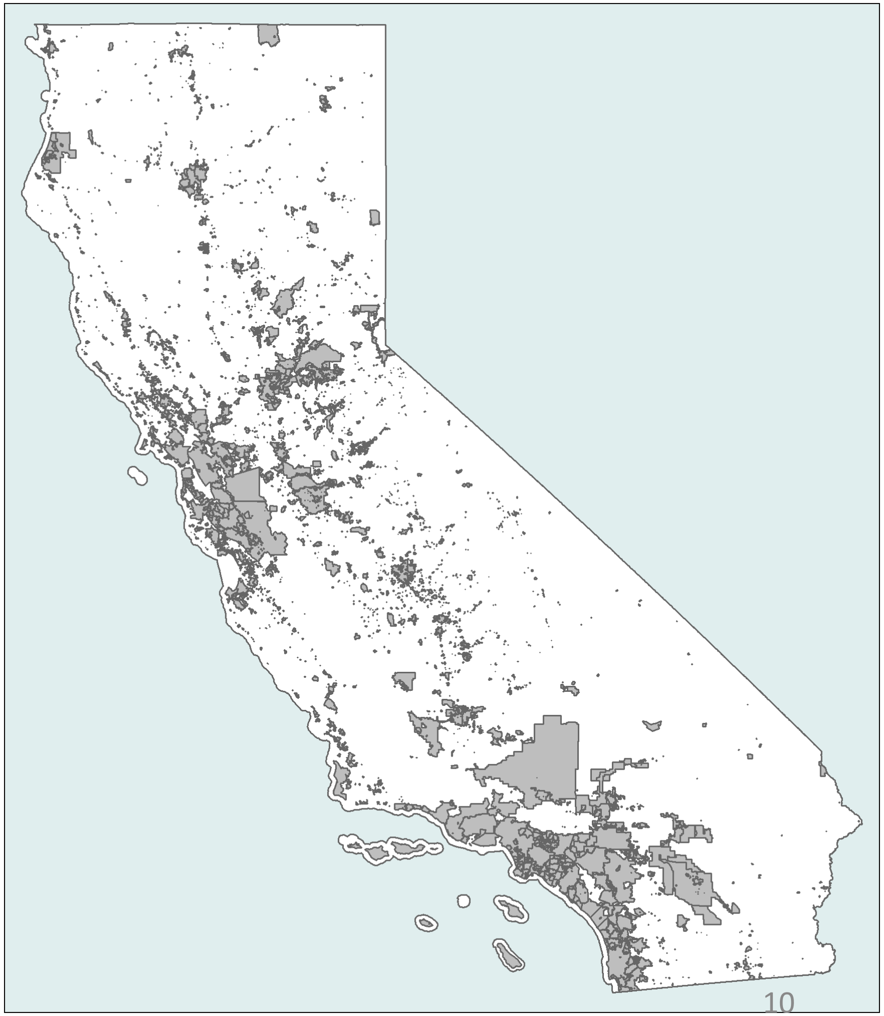
Water system included in 2019-2022 PFAS investigative orders — n = 595

↓

Participant's main source of water is not a private well — n = 590

↓

Not missing key variables — n = 563



Study population

n = 563

Sociodemographic Characteristics	Mean (SD) or N (%)
Age	
Mean (SD)	48.5 (16)
Gender	
Female	341 (61%)
Male	222 (39%)
Race/ethnicity	
Asian alone	51 (9%)
Black alone	54 (10%)
Hispanic any	228 (40%)
Multi-racial and other	30 (5%)
White alone	200 (36%)
Education	
Some high school or less	40 (7%)
High diploma or GED	63 (11%)
College/some college/trade/tech	338 (60%)
Graduate degree	122 (22%)
Income	
$25K or less	160 (28%)
$25,001 to $75,000	229 (41%)
$75,001 to $150,000	124 (22%)
More than $150K	50 (9%)

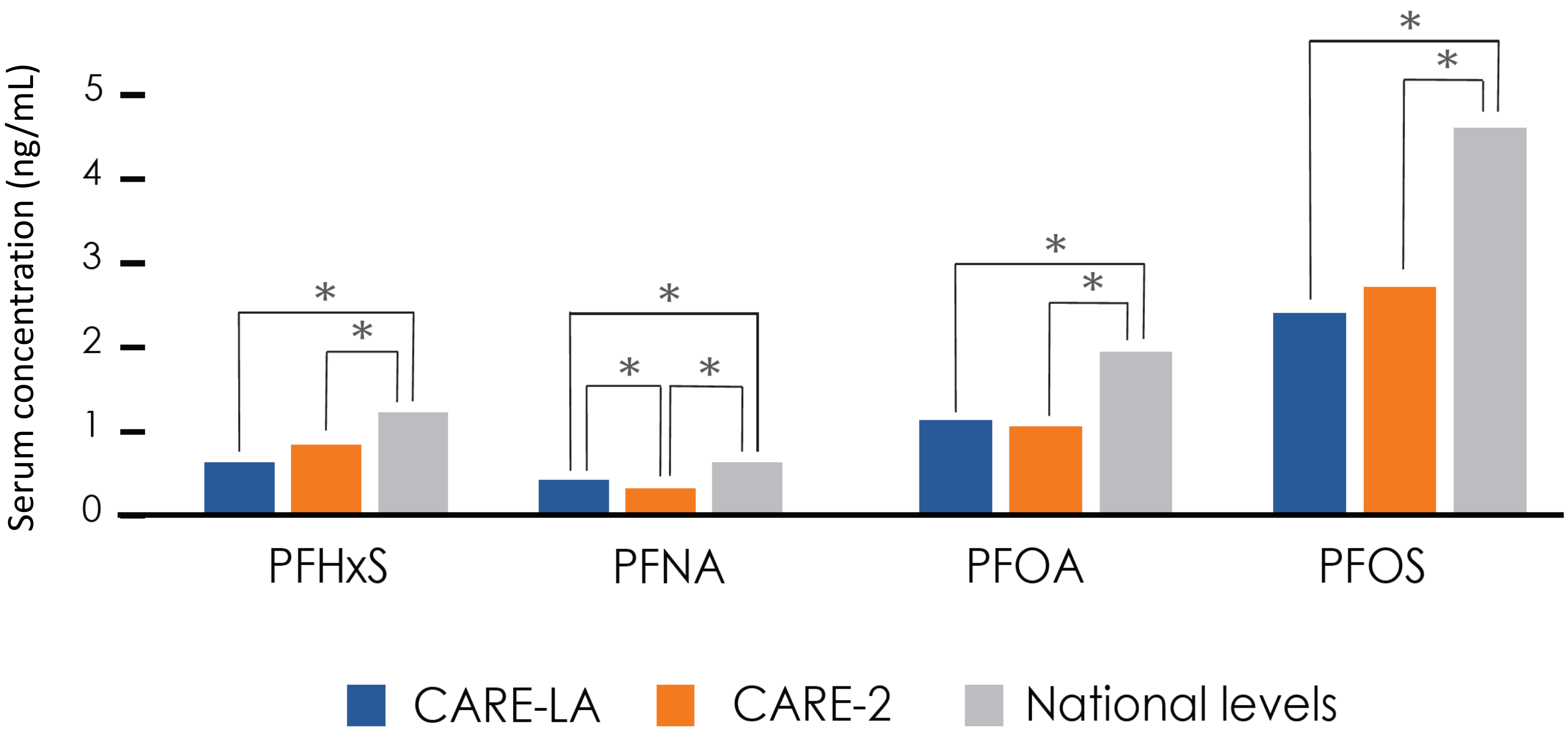
Serum concentrations were highest for PFOS, PFOA, and PFHxS

n = 563

Analyte	% Detects	Geometric mean
Et-PFOSA-AcOH	24.7	*
Me-PFOSA-AcOH	87.2	0.05
PFBS	8.3	*
PFDA	64.8	0.09
PFDoA	1.1	*
PFHpA	45.7	*
PFHxS	98.6	0.67
PFNA	94.0	0.26
PFOA	98.1	0.98
PFOS	97.2	2.08
PFUnDA	70.3	0.06

*Geometric means (ng/mL) are not calculated when the detection frequency is less than 65%

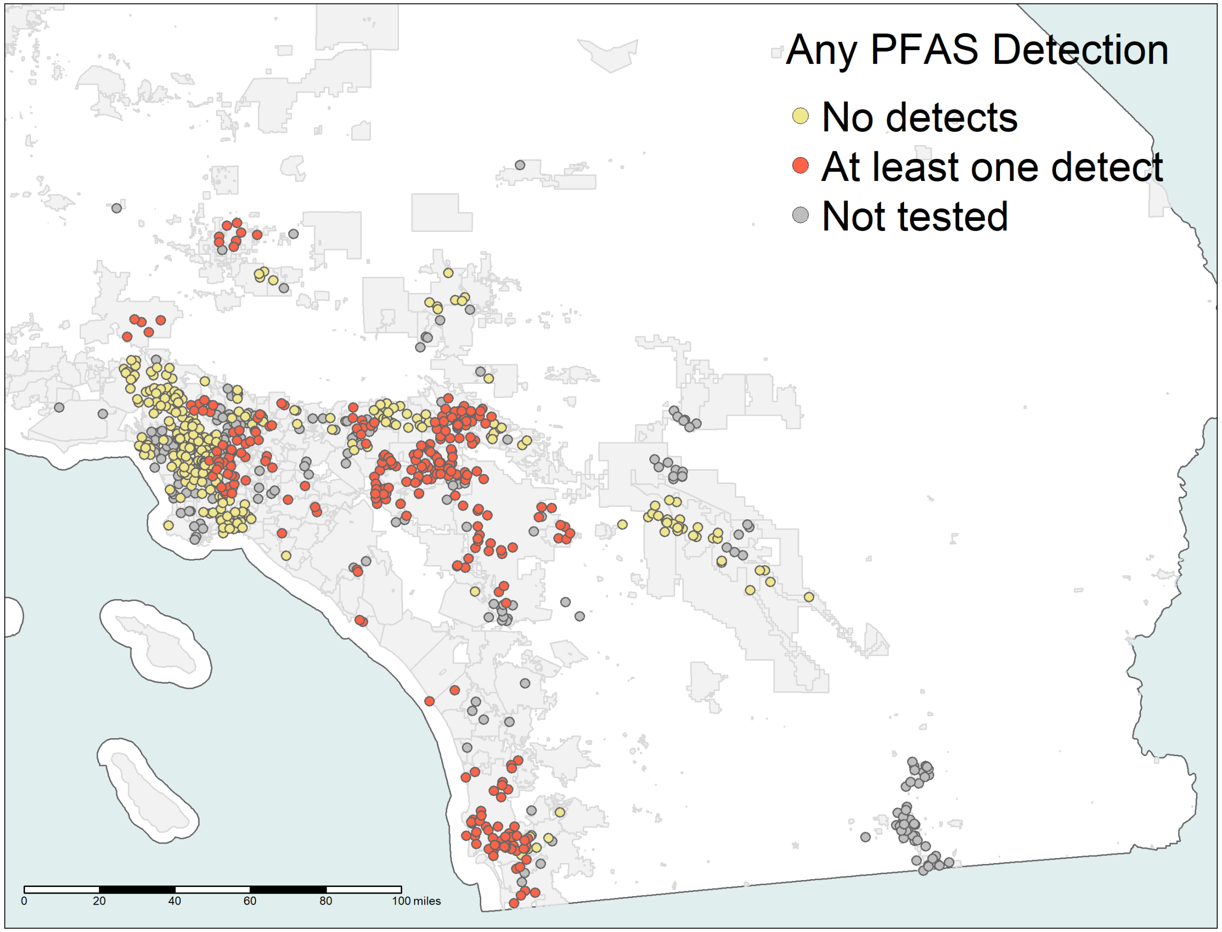
CARE participant serum PFAS concentrations were lower than national levels



* Indicates statistically significant comparison

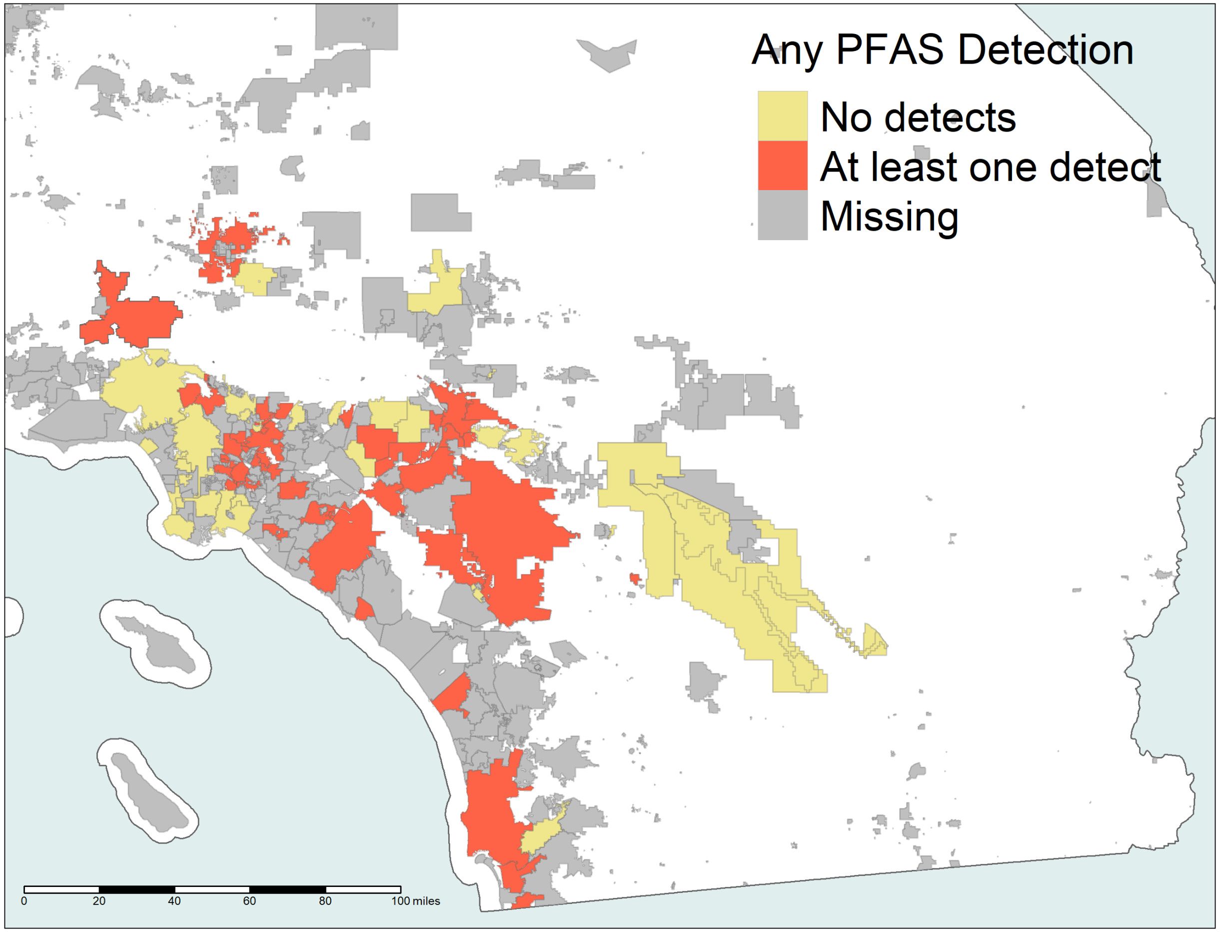
Nearly half of participants live in water systems with detections of PFASs

47% of participants (265 of 563) lived in a water system service area with at least one PFAS detection



Over half of water systems had PFAS detections

60% of water systems (42 of 70) had at least one PFAS detection



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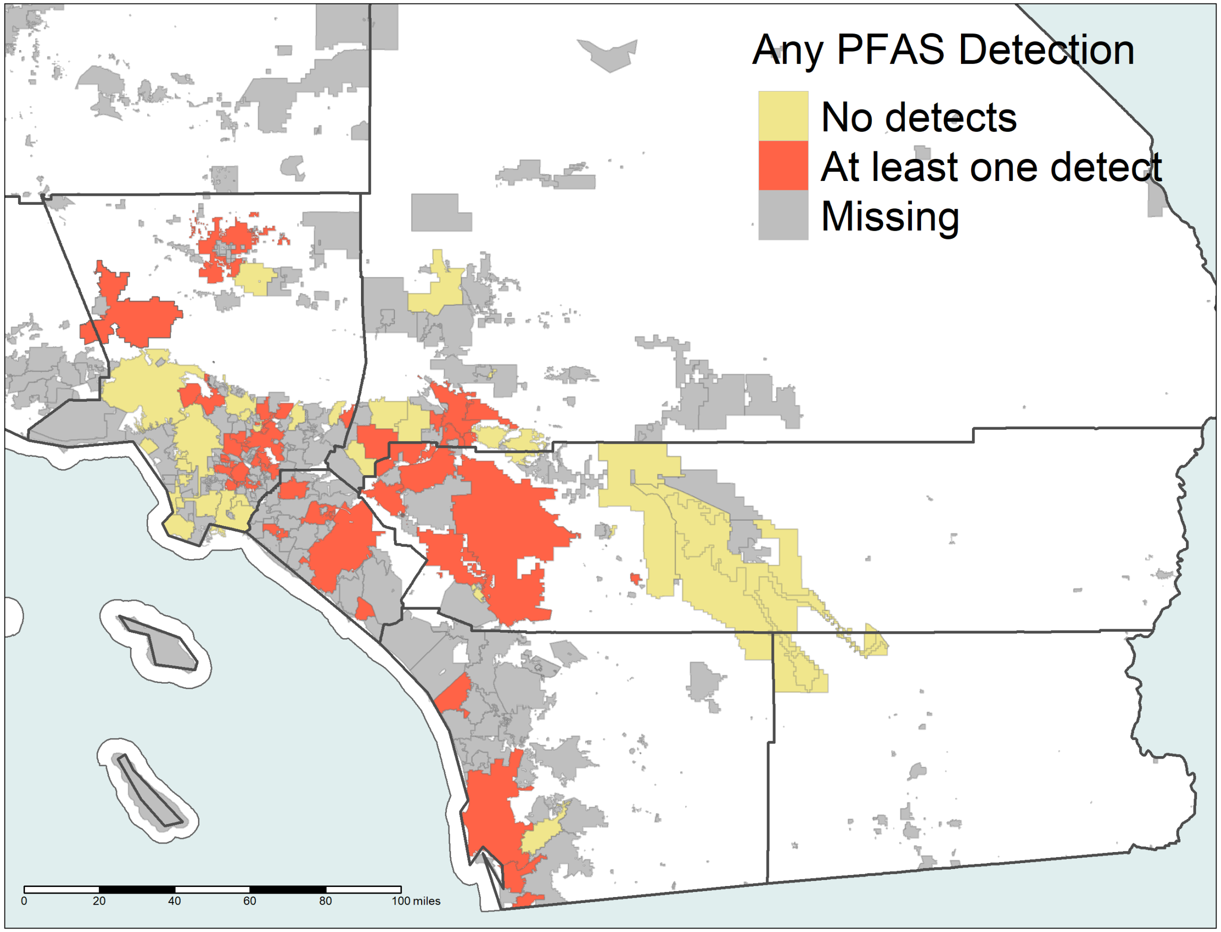
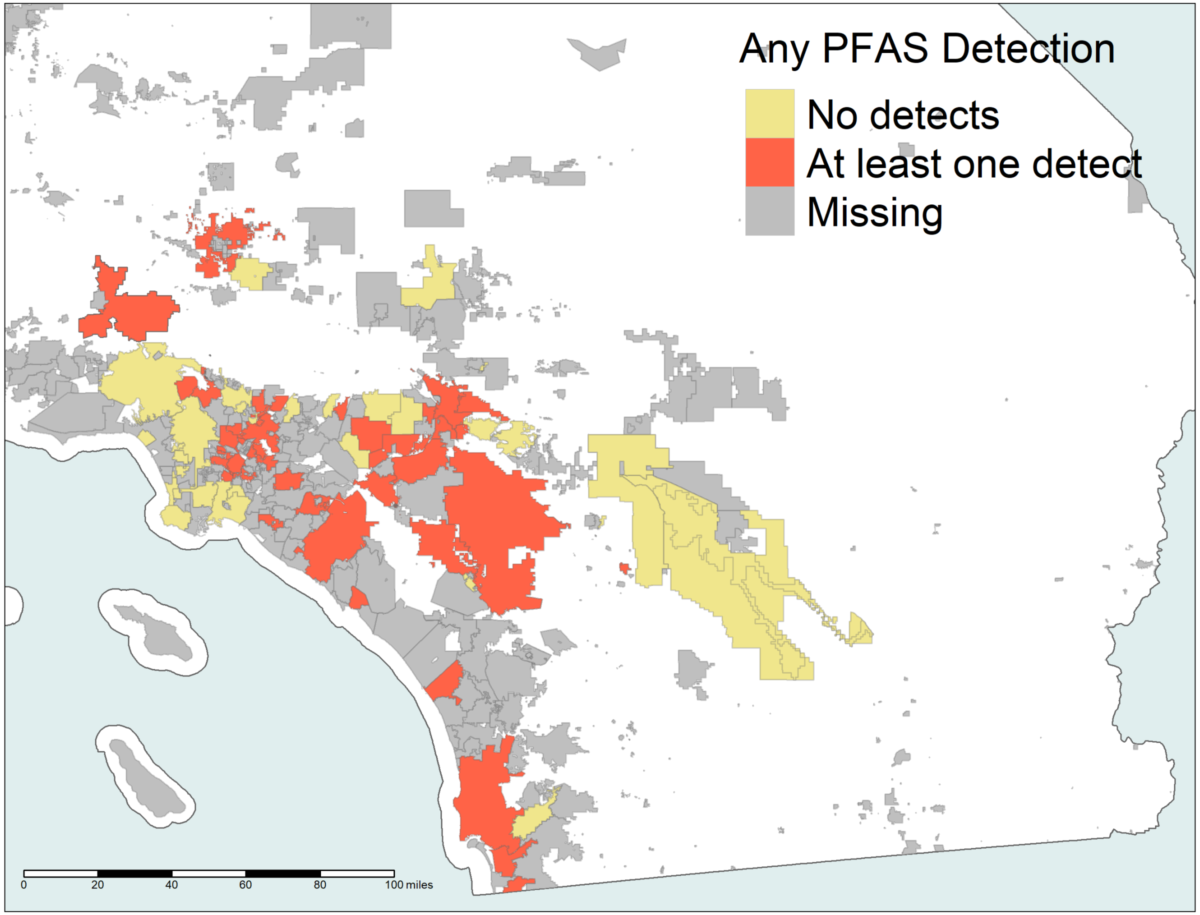


Over half of water systems had PFAS detections

60% (42 of 70) water systems had at least one PFAS detection

Water systems (n=70*) with at least one detection by analyte		
Analyte	**n**	**%**
Et-PFOSA-AcOH	2	2.9
Me-PFOSA-AcOH	0	0.0
PFBS	33	47.1
PFDA	5	7.2
PFDoA	0	0.0
PFHpA	21	30.0
PFHxS	34	48.6
PFNA	8	11.4
PFOA	34	48.6
PFOS	33	47.1
PFUnDA	0	0.0

* Total n differs for some analytes



PFHxS, PFOA, and PFOS had high detection frequencies in both water and serum

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PFNA	8	11.4
PFOA	34	48.6
PFOS	33	47.1
PFUnDA	0	0.0

* Total n differs for some analytes

Serum PFAS detections and geometric means		
Analyte	%	GM
Et-PFOSA-AcOH	24.7	*
Me-PFOSA-AcOH	87.2	0.05
PFBS	8.3	*
PFDA	64.8	0.09
PFDoA	1.1	*
PFHpA	45.7	*
PFHxS	98.6	0.67
PFNA	94	0.26
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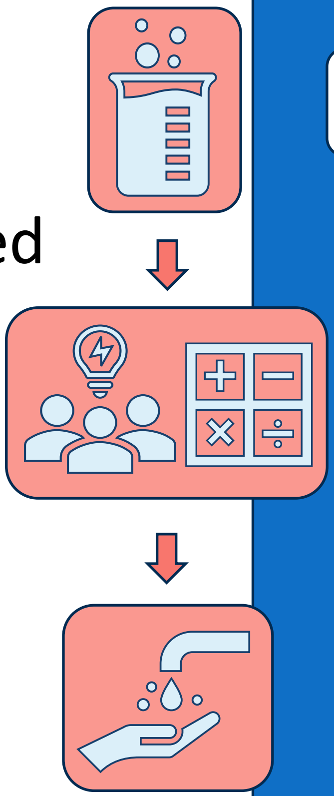
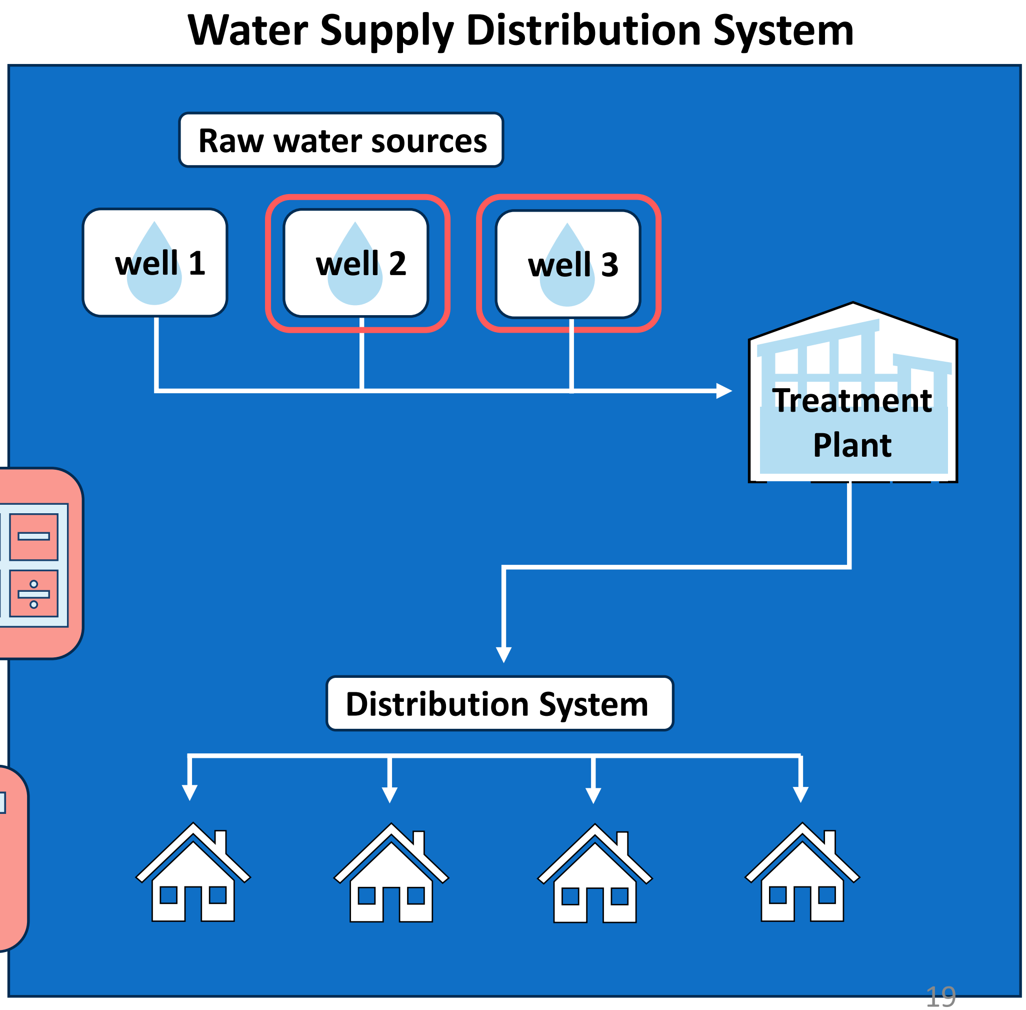
- Included in final analysis:
  - **PFHxS, PFOA, PFOS**
  - **∑11 PFAS:** sum of 11 PFAS that overlap in CARE and Water Board testing

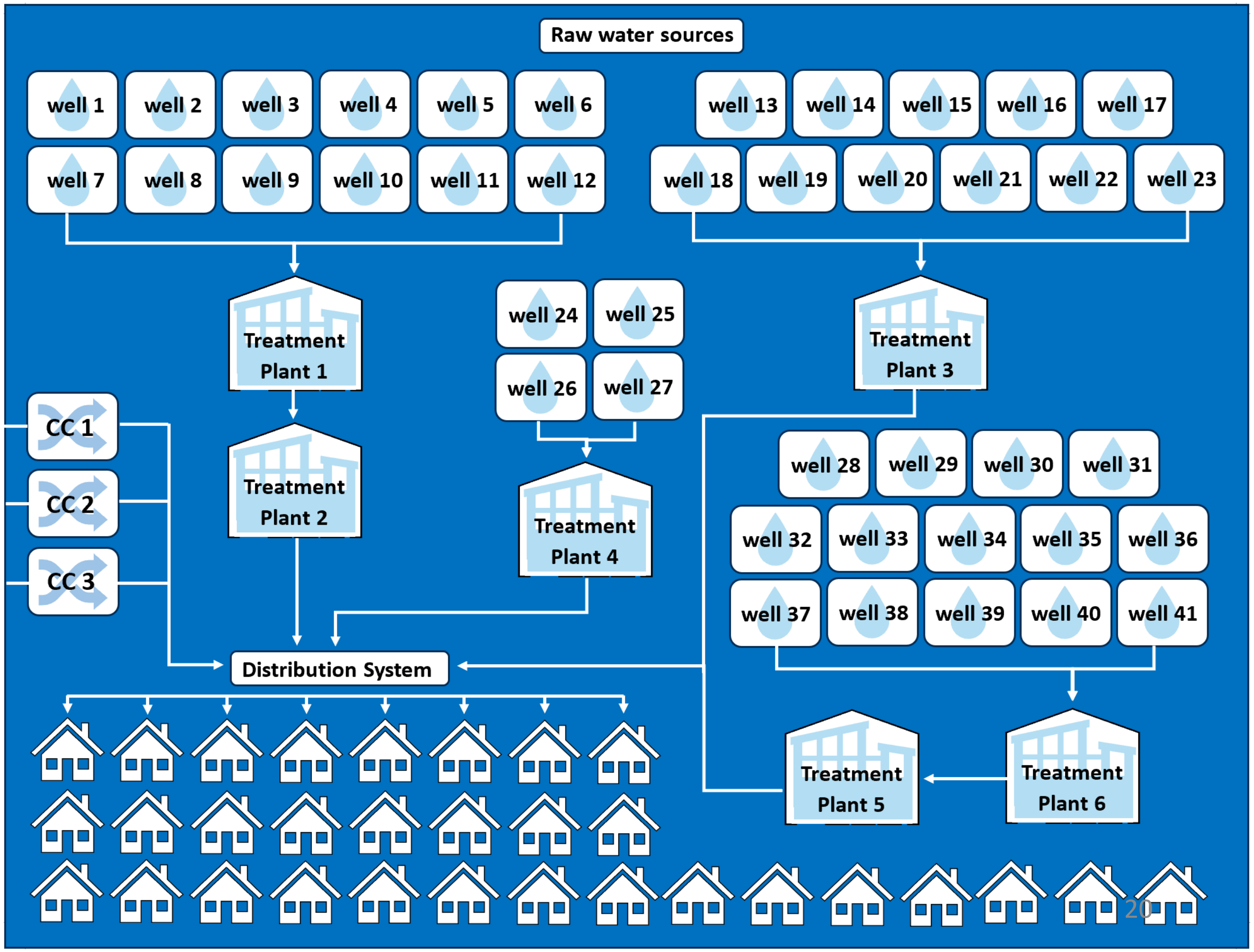
Assignment of drinking water exposure indicator

- Ideal goal: estimate finished water levels



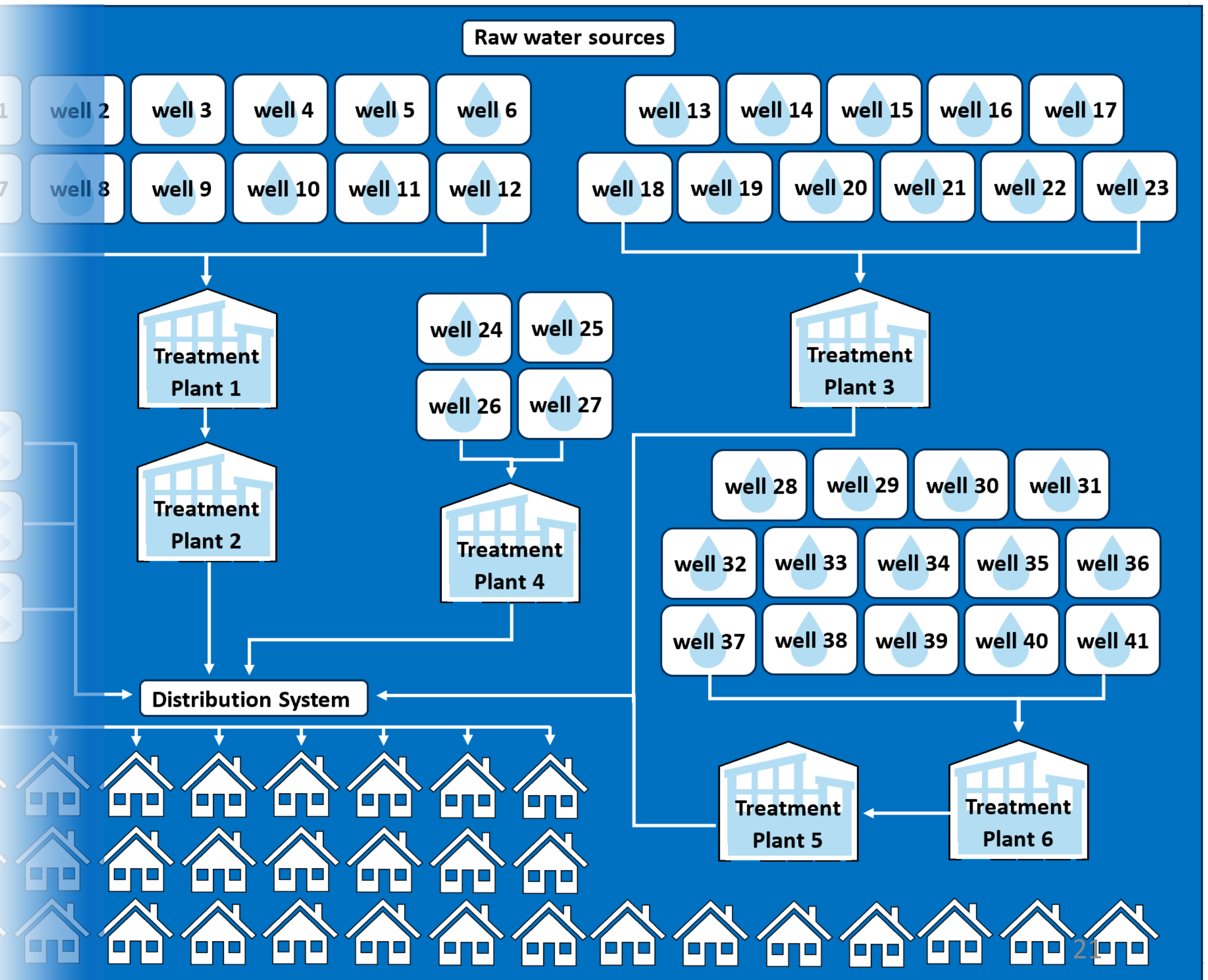


Assignment of drinking water exposure indicator



Assignment of drinking water exposure indicator

- Challenges:
  - Sampling is primarily from raw sources and not finished water
  - No water blending / mixing / volume data
  - Data coverage differs by water system



Assignment of drinking water exposure indicator

- Binary category based on statewide required reporting limits (4 ng/L)
  - No PFAS detections
  - At least one PFAS detection

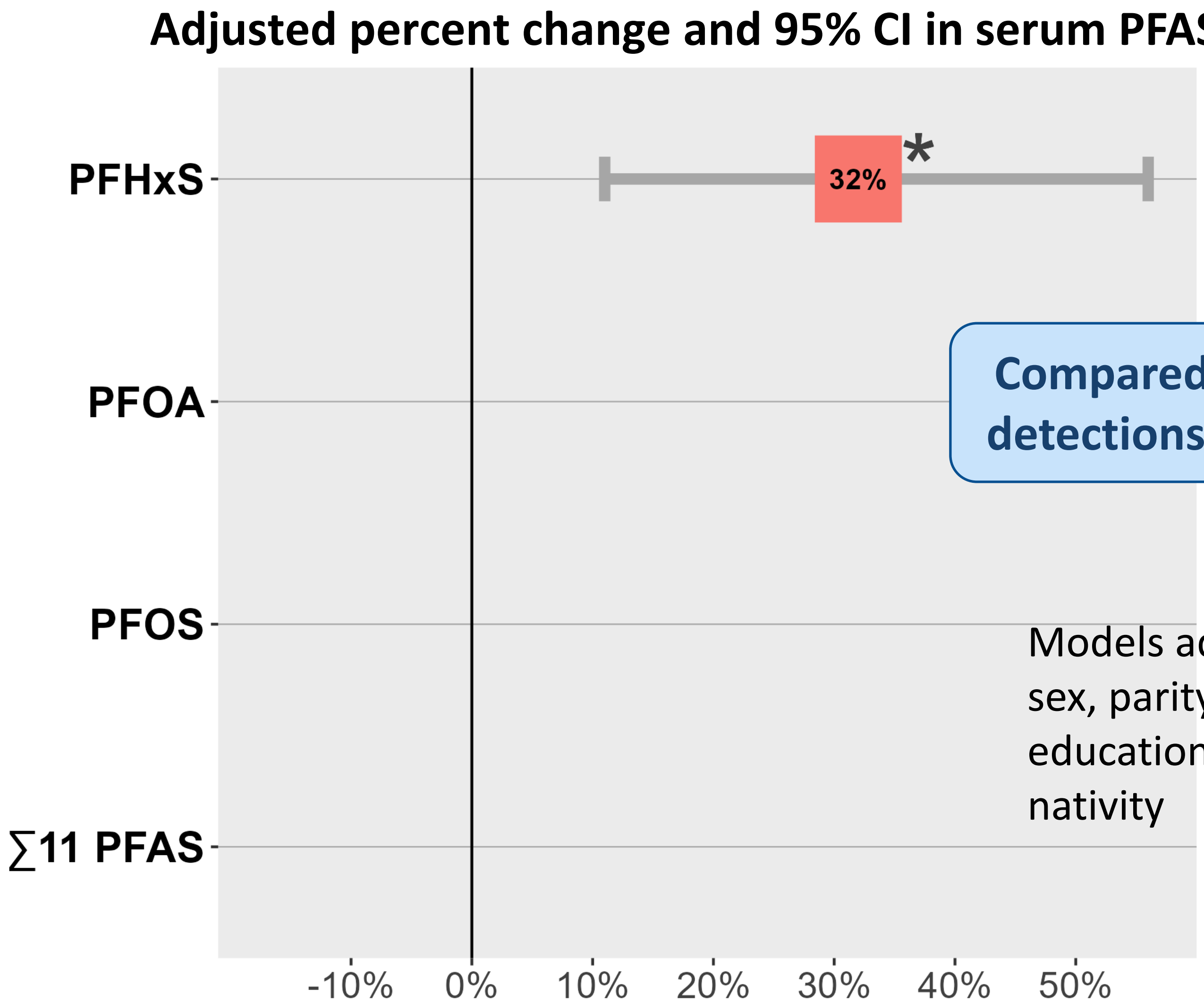
- For analytes:

PFHxS
PFOA
PFOS
∑11 PFAS

Statistical analysis

- Log-transformed serum concentrations
- Associations between binary PFAS detection categories and serum PFAS
  - Multivariable linear regression
  - Covariates included: age, sex, parity, race/ethnicity, education, income, and nativity

Associations between drinking water and serum PFASs

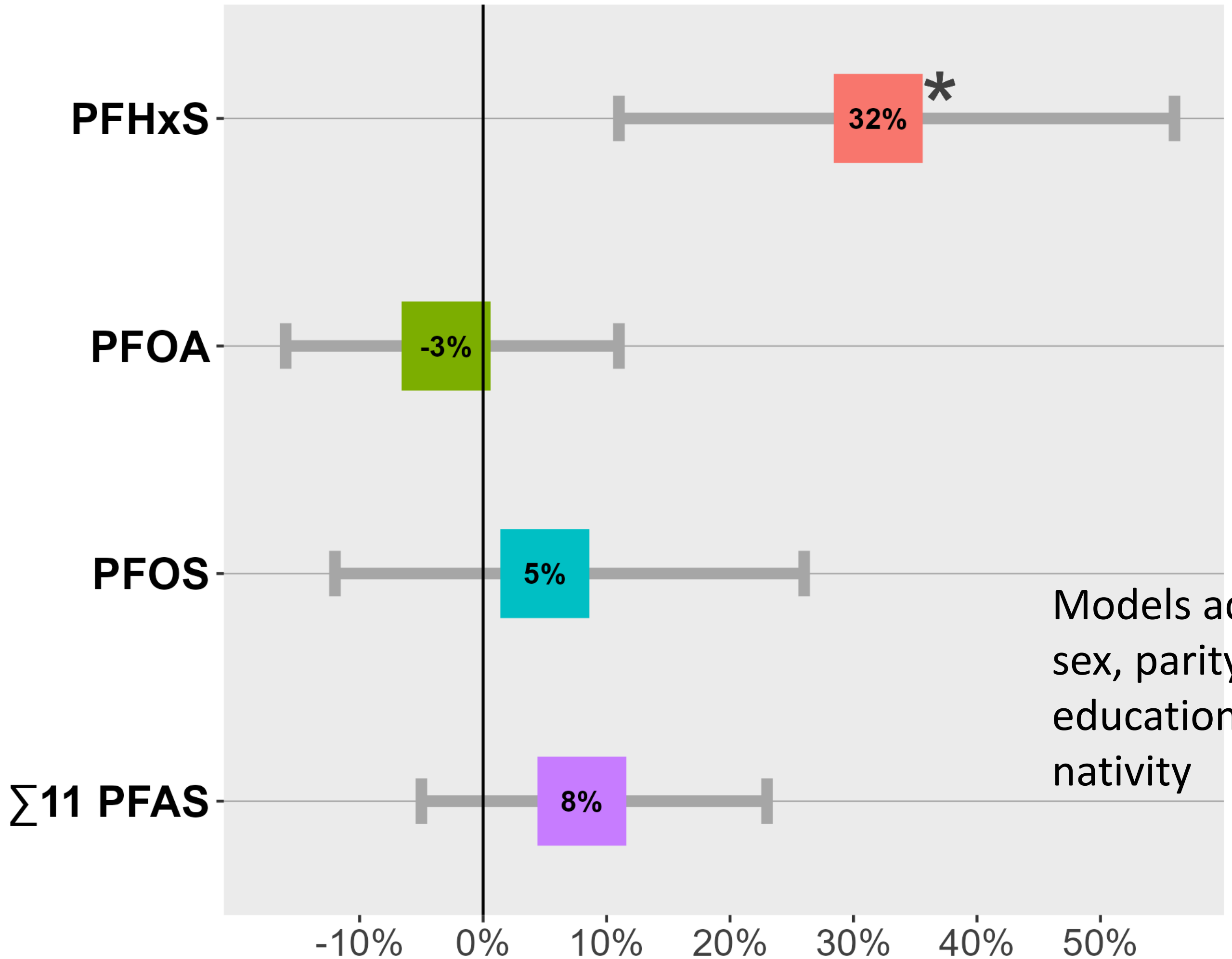


Compared to no detections group

Models adjusted for age, sex, parity, race/ethnicity, education, income, and nativity

Participants living in water system service areas with PFHxS detections had higher serum levels

Adjusted percent change and 95% CI in serum PFASs



Models adjusted for age, sex, parity, race/ethnicity, education, income, and nativity

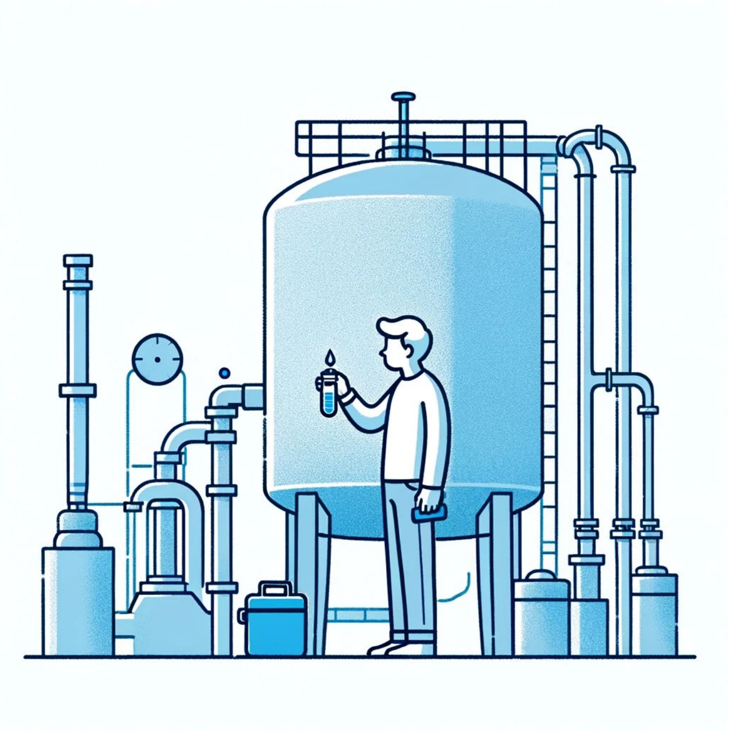
Summary and conclusions

In this general population of adults in Southern California, PFHxS contamination in drinking water may be a significant contributor to serum PFHxS levels.

Results from this study align with literature demonstrating drinking water can contribute to PFAS exposure.

Implications and significance

- Development of health protective drinking water concentrations
- Impending EPA National PFAS Maximum Contaminant Levels (MCLs)
  - Addressing PFAS contamination in water can require time and financial resources
  - These results help support enforcement of MCLs



Acknowledgements

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BIOMONITORING CALIFORNIA
MEASURING CHEMICALS IN CALIFORNIANS

CDPH

DTSC
Department of Toxic Substances Control

CALIFORNIA Water Boards | State Water Resources Control Board

OEHHA
California Office of Environmental Health Hazard Assessment

Questions?

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