PFAS
Human Health Effects

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The C8 Science Panel

- **Class action lawsuit mandated the study of PFOA and health effects**
  - 69,030 participants
  - Blood samples, medical records and questionnaires
- **Blood PFOA levels were relatively high**
  - C8-panel study ~32.9 ng/mL
  - NHANES ~4-5 ng/mL
- **Determined if any disease is "more probably than not" to be associated with PFOA exposure**
  - 55 health outcomes studied (2011-2012)

Frisbee SJ., *et al*. *Environmental Health Perspectives* 117.12 (2009): 1873-1882.

C8 Science Panel Findings

- Health outcomes with *probable* links to PFOA
  - Kidney cancer
  - Testicular cancer
  - Ulcerative colitis
  - Thyroid disease
  - Hypercholesterolemia
  - Pregnancy-induced hypertension

- Most studies prior or after the C8 Health Project
  - Adult males in occupational settings
  - High exposure levels
  - Study either PFOA or PFOS

http://www.c8sciencepanel.org/

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Prenatal and Early Childhood Exposure

- **Birth cohorts: prenatal and postnatal PFAS measurements**
  - Decreased vaccine response/effectiveness
  - Strong associations for joint exposure (PFOS, PFOA, PFHxS)
  - At relatively low/common exposure levels
  - Other studies have replicated associations

- **Other childhood outcomes studied**
  - Fetal and postnatal growth
  - Limited evidence on neurodevelopmental toxicity (mixed findings)
  - Potential for live-birth selection bias

Liew Z., et al. *Current Environmental Health Reports* 5.1 (2018): 1-19.

ATSDR – Profile on PFAS (2018)

- Epidemiological Evidence

Health Outcomes	Endpoints Evaluated	PFAS
Hepatic	↑Serum enzymes; ↓Serum bilirubin	PFOA, PFOS, PFHxS
	↑Serum lipids (Cholesterol & LDL)	PFOA, PFOS, PFNA, PFDeA
Cardiovascular	↑Risk pregnancy-induced hypertension or pre-eclampsia	PFOA, PFOS
Endocrine	↑Risk of thyroid disease	PFOA, PFOS
Immune system	↓Antibody response	PFOA, PFOS, PFHxS
	↑Risk of asthma diagnosis	PFOA
Reproduction	↓ Fertility	PFOA, PFOS
Developmental toxicity	↓ Birthweight (small magnitude)	PFOA, PFOS
Cancer	↑ Testicular ↑ Kidney	PFOA

Source: Agency for Toxic Substances and Disease Registry (ATSDR). 2018. Toxicological profile for Perfluoroalkyls. (Draft for Public Comment). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

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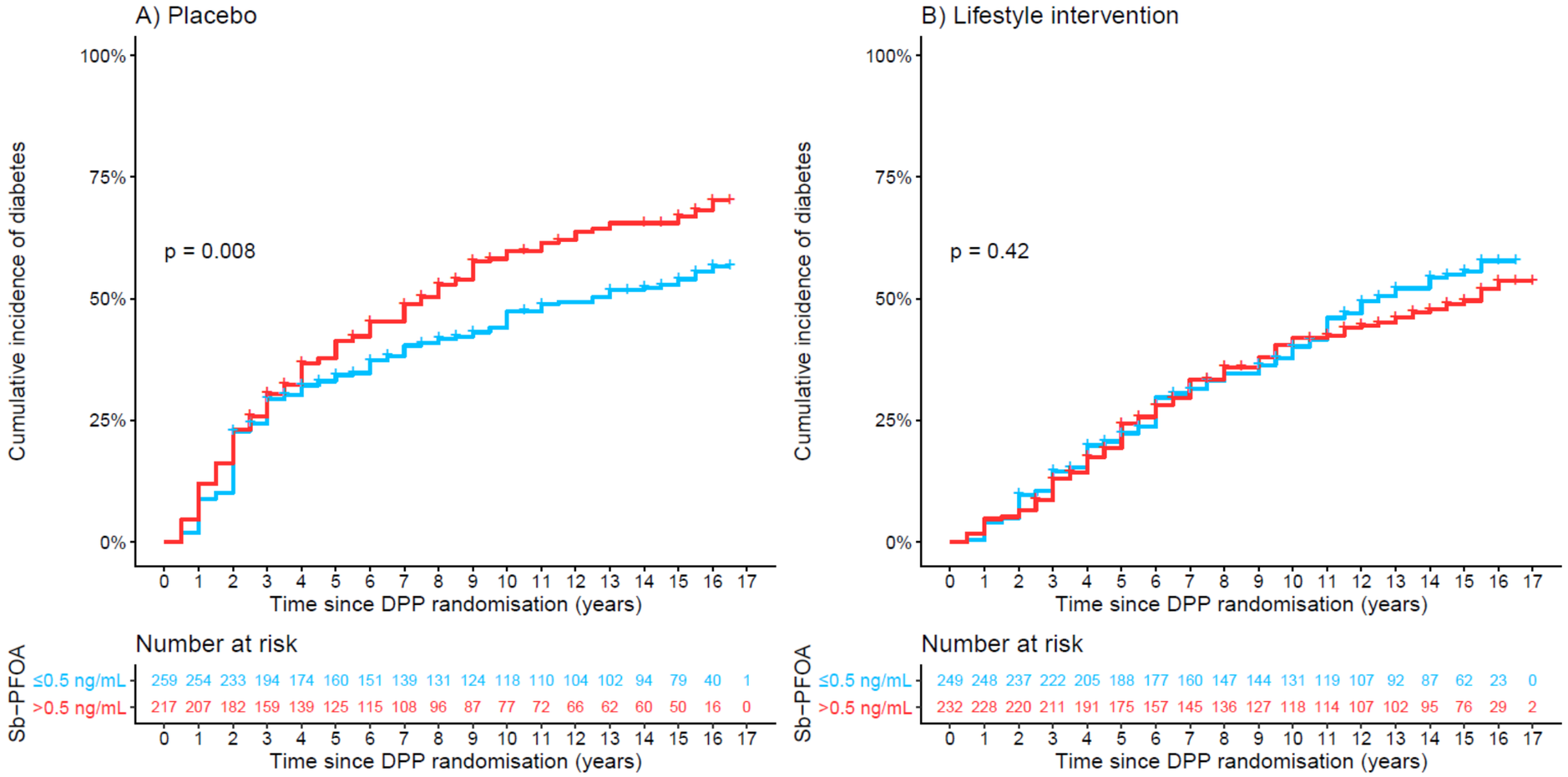
PFAS as Endocrine Disruptors

- Associations with Type 2 Diabetes
  - Prospective study have shown increased risk
    - PFOA/PFOS ↑Diabetes risk (Sun Q., et al. *EHP* 126.3 (2018): 037001)
    - PFOA ↑ Diabetes Incidence (Cardenas A., *Diabetes Care* 42.9 (2019): 1824-1832.)



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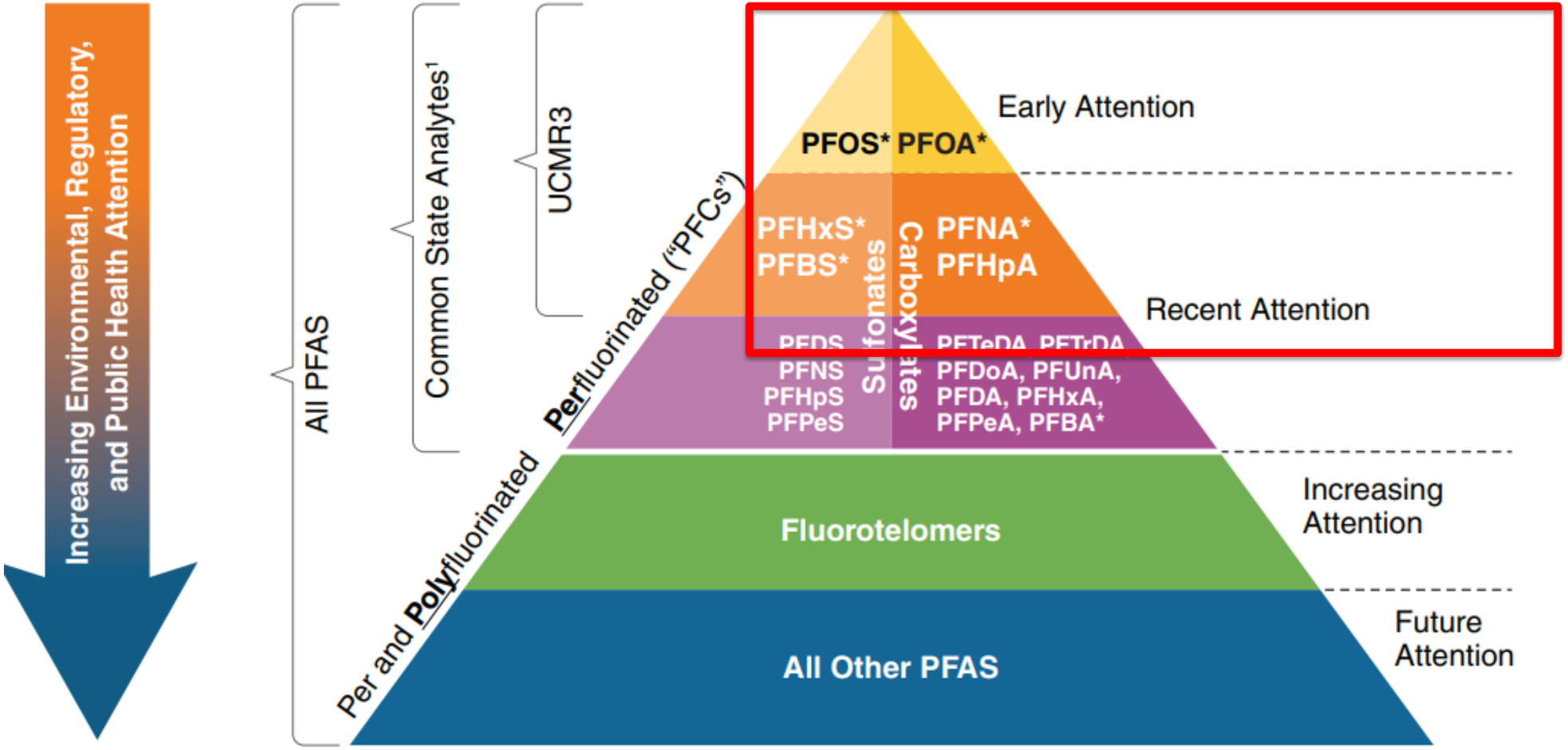
Limited Scope

- Only tested a handful of legacy PFAS



Source: Interstate Technology & Regulatory Council (ITRC); https://pfas-1.itrcweb.org/

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Limited Scope

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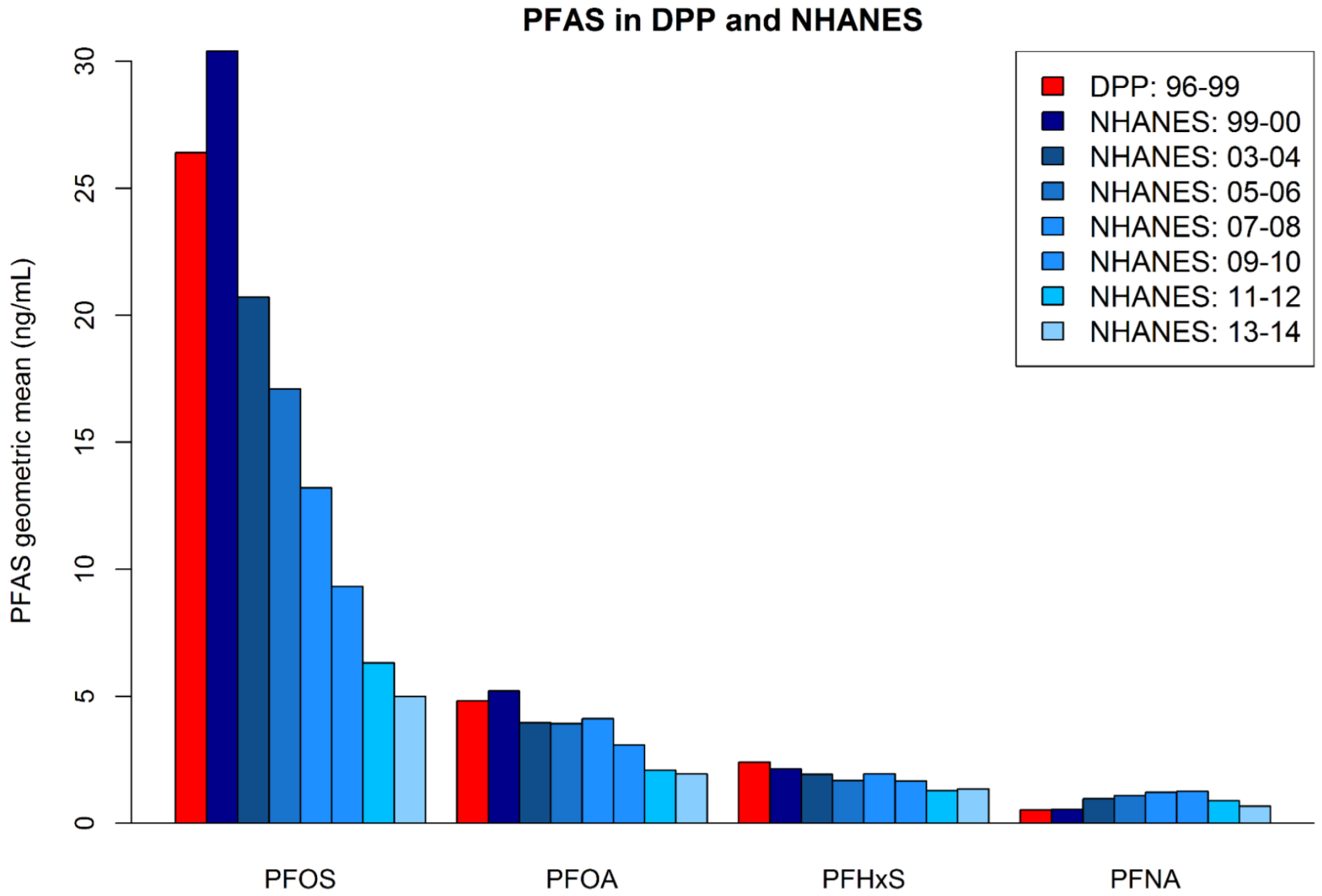

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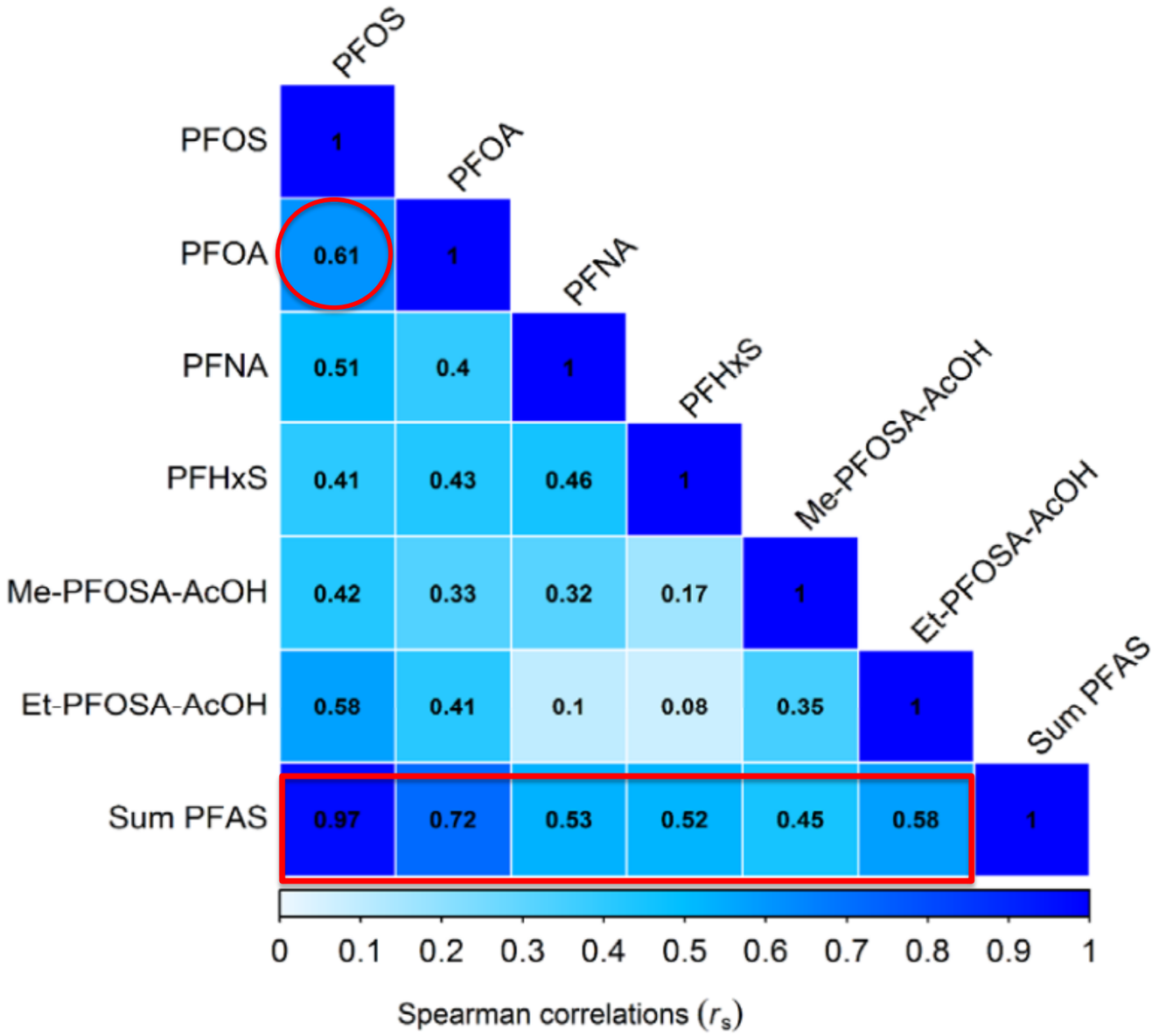
Correlated Human Biomarkers



Cardenas A., et al. *JAMA* Net Op. 1.4 (2018)

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Future Directions

- **Biomonitoring of affected communities**
  - Should we monitor PFAS similar to Pb?
- **Early molecular biomarkers of disease**
  - Metabolomics
  - Genomic signatures (multi-omics)
- **We can’t design studies to test ~5,000 PFAS**
  - KCs of endocrine-disrupting chemicals could help target studies
  - At low exposure levels reverse causation is problematic
    - Prospective and interventional studies
  - **Exclusive vs. generalizable** effects/toxicity of PFAS family

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Discussion & Questions

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