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)

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/]
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

## ATSDR – Profile on PFAS (2018)

### Epidemiological Evidence

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

- Only tested a handful of legacy PFAS

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

- Handful of legacy PFAS
Correlated Human Biomarkers

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
Discussion & Questions

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