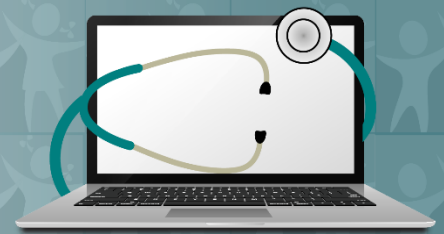




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# **Perfluoroalkyl Substances (PFAS): Potential Exposure Sources, Potential Health Impacts, and Guidance for Clinicians**

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# Conflict of Interest Statement

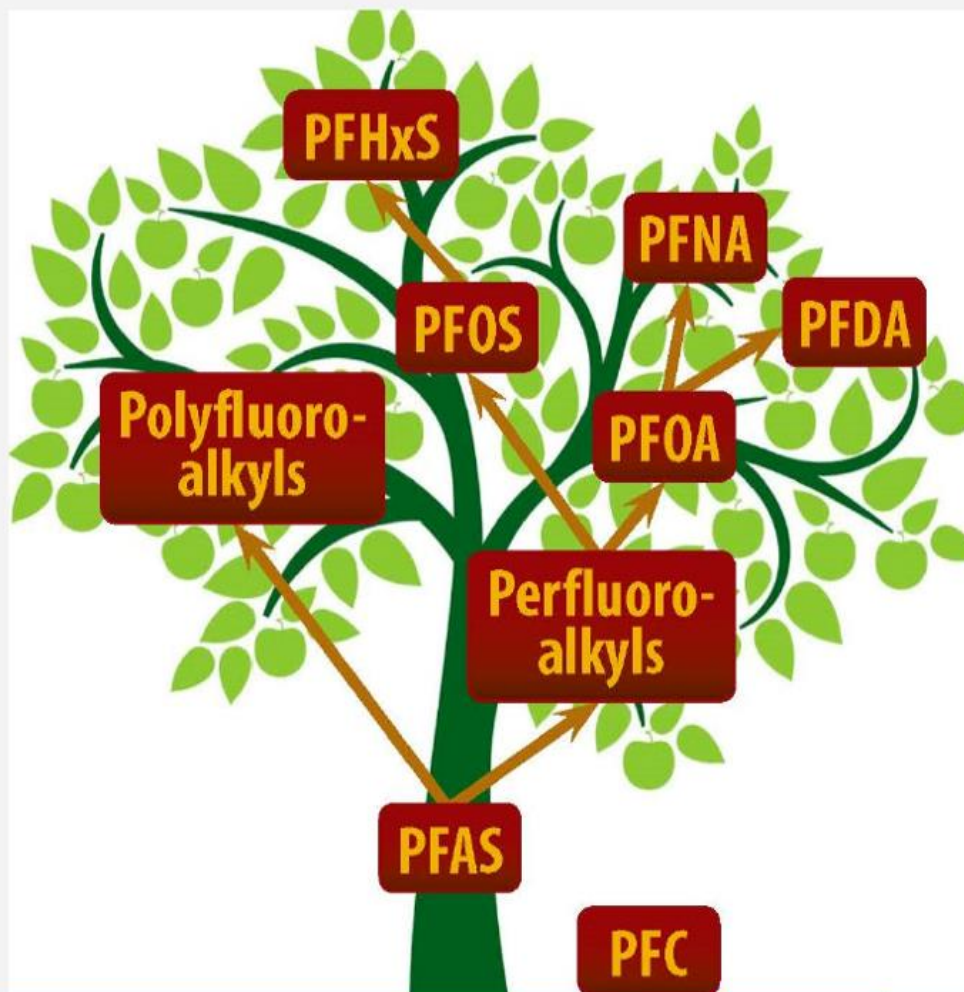
- *In the past 12 months, we have had no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity.*
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# Objectives

1. Define the chemical family of perfluoroalkyl substances (PFAS) and where they can be found.
2. Identify the scope of potential exposure across the United States.
3. Describe potential health impacts in children.
4. Discuss implications for clinicians.

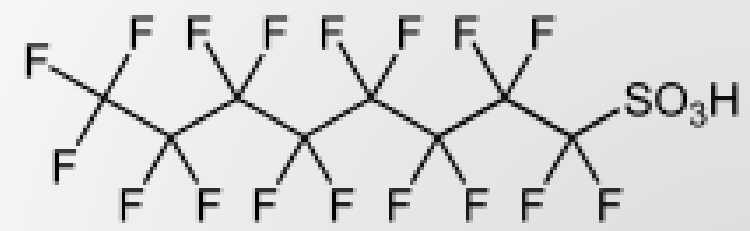
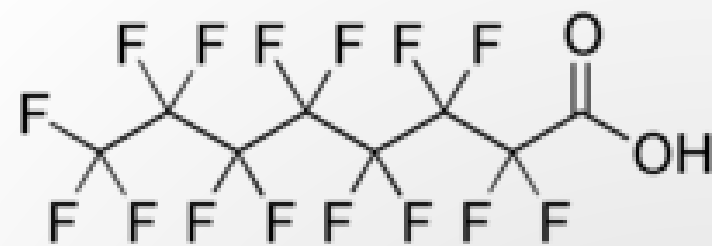
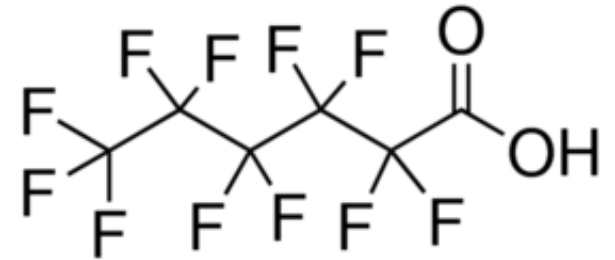
# What are PFAS?

## PFAS Family Tree



# Properties of PFAS

- **PFOA - perfluorooctanoate**
- **PFOS – perfluorooctane sulfonate**
- **PFHx – perfluorohexanoate**
- **Stain-resistant**
- **POPs – long half-lives, lipophilic**
- **PFOS ceased production 2002**
- **PFOA out of production in 2015**



# Perfluoralkyl Substances(PFAS)

- PFAS are widely used to make everyday consumer products
- Resistant to stains, heat, oil, grease, and water, and also act as lubricants
- Extremely persistent in the environment and resistant to typical degradation processes
- The half-life, or the amount of time it takes for 50% of the chemical to leave the human body is measured in years.
- This slow elimination time makes it difficult to determine how changes in lifestyle, diet, or other exposure-related factors influence blood levels  
(NIEHS, 2012).



# PFAS Basics



## PFAS Basics

### ■ Uses

- Non-stick cookware
- Carpet and clothing treatments
- Paper and cardboard packaging
- AFFF fire-fighting foam

### ■ Sources

- Waste from manufacturing facilities
- Fire-fighting foam run-off
- PFC-containing sludge used as soil amendment

### ■ Exposure Pathways

- Drinking water
  - ❖ Private residential wells, municipal systems
- Air and dust
- Fish (in contaminated areas)
- Consumer products
  - ❖ Food containers/wrapping
  - ❖ Clothing
  - ❖ Cookware
- Produce





What other potential exposure points and pathways exist for PFAS?

# Wisconsin House Dust

Perfluorinated chemicals found in vacuum dust samples from 39 Wisconsin homes.

Congener	Detection Freq <sup>a</sup> (%)	Median (range) ng/g
Perfluorooctane sulfonate (PFOS)	100	47 (8.7–1100)
Perfluorooctanoic acid (PFOA)	100	44 (6.5–420)
Perfluoroheptanoic acid (PFHpA)	100	17 (2.4–140)
Perfluorohexane sulfonate (PFHxS)	100	16 (2.1–1000)
Perfluorononanoic Acid (PFNA)	100	12 (1.3–280)
Perfluoroheptane sulfonate (PFHpS)	97	9.9 (ND-37)
Perfluorodecanoic acid (PFDA)	72	5.7 (ND-60)
Perfluorodecane sulfonate (PFDS)	95	5.4 (ND-120)
Perfluoropentanoic acid (PFPA)	97	5.4 (ND-32)
Perfluorododecanoic acid (PFDoA)	95	5.0 (ND-41)
Perfluorotetradecanoic acid (PFTeA)	97	3.7 (ND-24)
Perfluorobutanoic acid (PFBA)	97	3.5 (ND-64)
Perfluoroundecanoic acid (PFUA)	87	3.1(ND-48)
Perfluorotridecanoic acid (PFTrA)	92	2.1 (ND-11)
Perfluorobutane sulfonate (PFBS)	59	1.8 (ND-31)
Perfluorohexanoic acid (PFHxA)	20	0 (ND-180)
Total perfluorinated chemicals	100	280 (70–2513)

<sup>a</sup> Reporting limit = 1 ng/g.

# Other Potential Exposure Sources

- Cord Blood
- Breast Milk
- Occupational Settings



## Why is this important?

**Widespread  
human  
exposure**

**May affect  
developing fetus  
and child**

**“contaminant of  
emerging  
concern” – EPA**

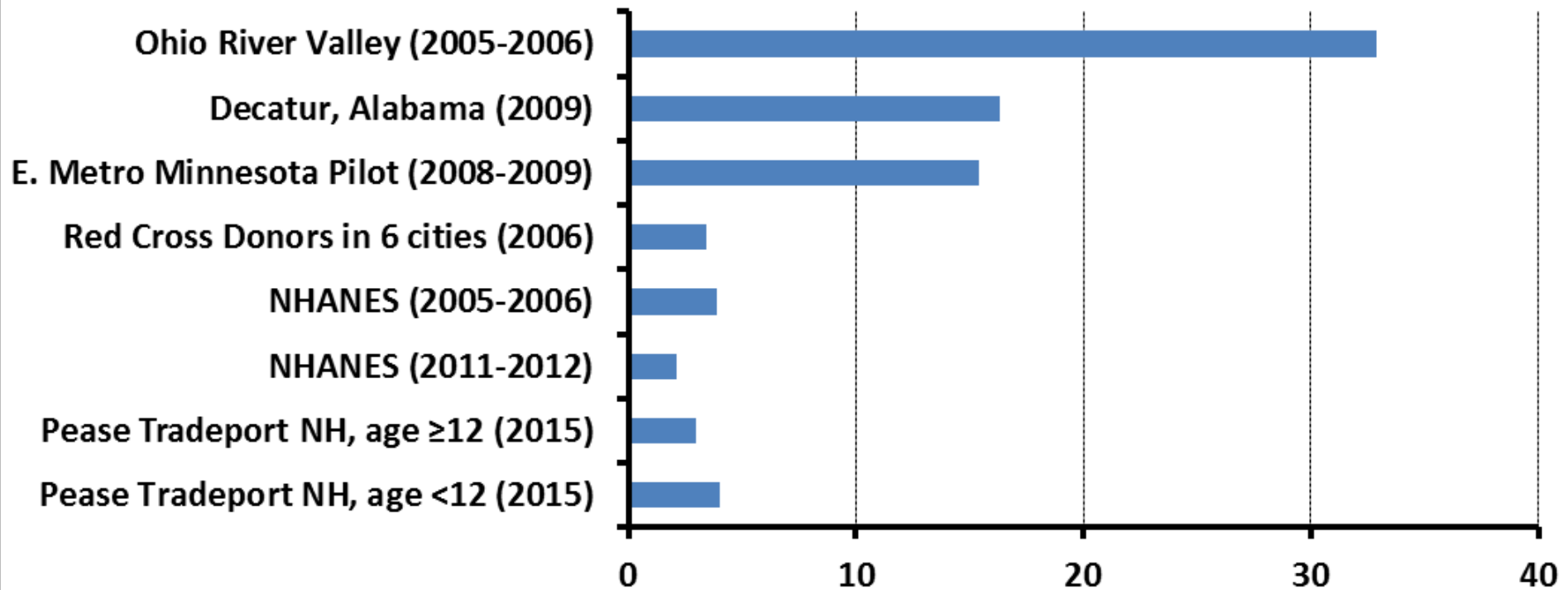
**Long half-lives  
in humans**

**May  
bioaccumulate  
in people**

**May increase  
cancer risk**

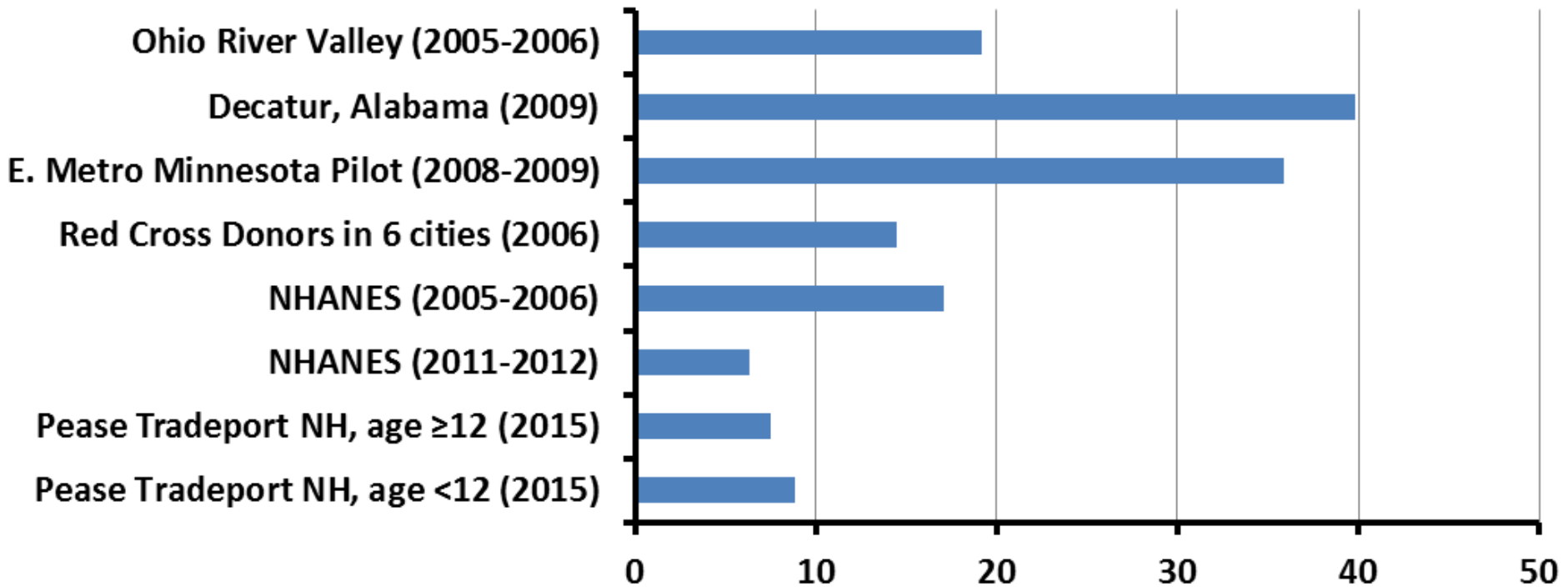
**PFAS levels  
exceed EPA’s  
LTHA in drinking  
water in several  
states**

## PFOA Geometric Mean Serum Concentration ( $\mu\text{g/L}$ ) in Various Study Populations (Environmentally Exposed Communities, & General U.S. Population)

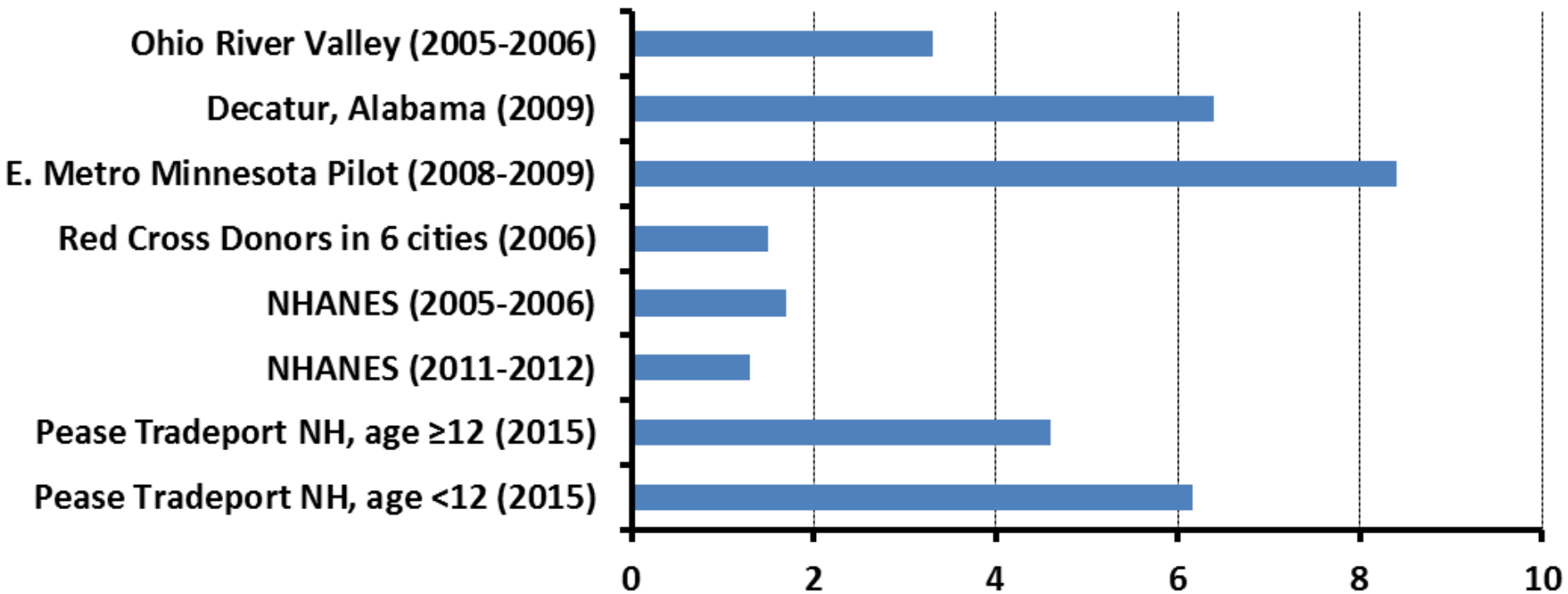


# PFOS

## PFOS Geometric Mean Serum Concentration ( $\mu\text{g/L}$ ) in Various Study Populations (Environmentally Exposed Communities, & General U.S. Population)



## PFHxS Geometric Mean Serum Concentration ( $\mu\text{g/L}$ ) in Various Study Populations (Environmentally Exposed Communities, & General U.S. Population)





# Perfluoralkyl Substances (PFAS)

PFOS and PFOA primarily accumulate in:

- Serum
- Kidney
- Liver

(ATSDR, 2016).

- Animal research indicates that PFAS are absorbed in the GI tract with no quantitatively significant metabolism of PFOA and PFOS following oral exposure.
- Research suggests that PFAS are not metabolized or undergo chemical reactions in the body.

(ATSDR, 2015).

# Potential Health Effects – Further Research Needed

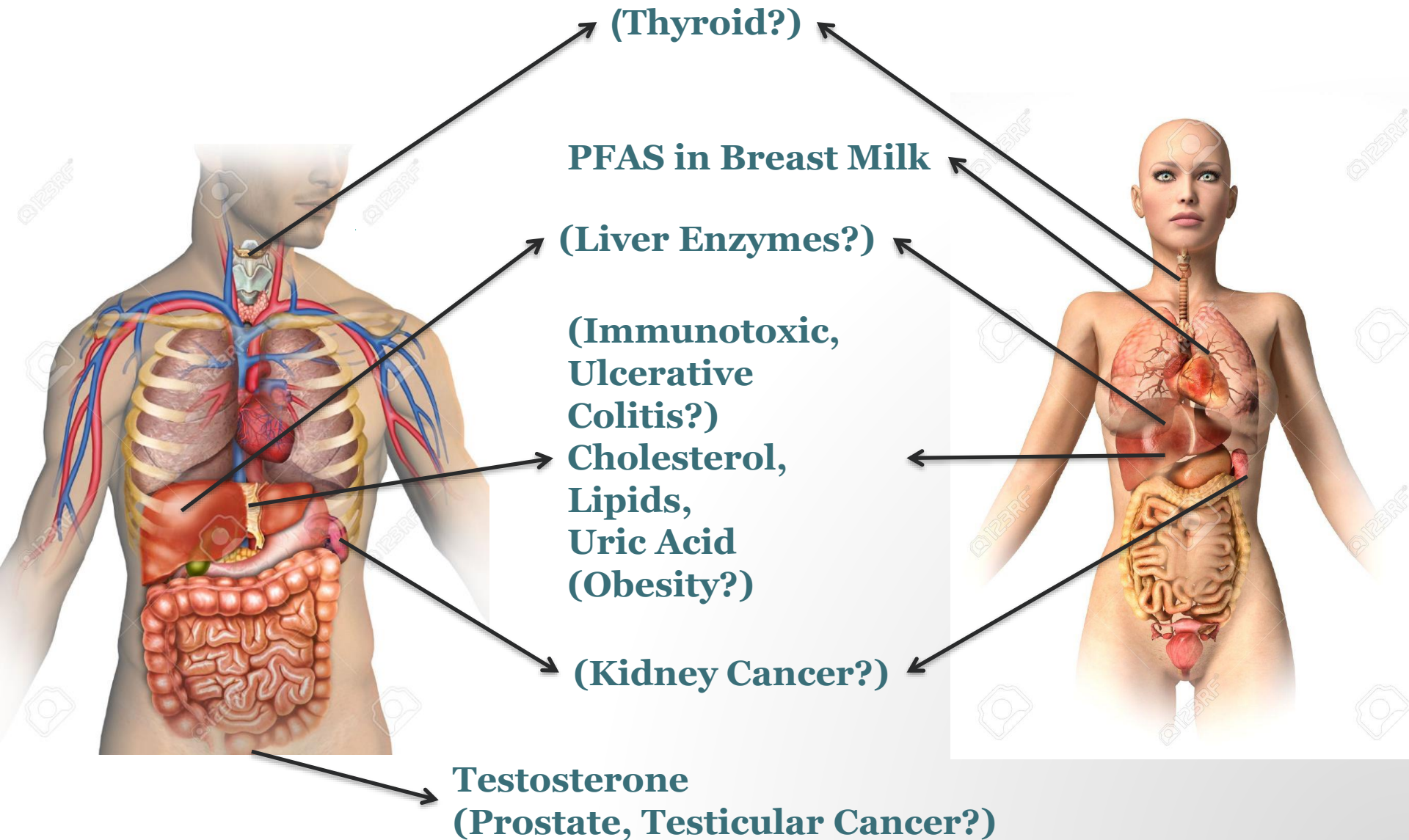
## **Animals**

- Increased liver weight (critical effect)
- Spleen, thymus, and developmental
- Cancer – liver, testis, pancreas

## **Humans**

- Possible changes in growth, learning and behavior
- Decreased fertility
- Increased cholesterol
- Immune effects
- Cancer – kidney, bladder, testicular, prostate

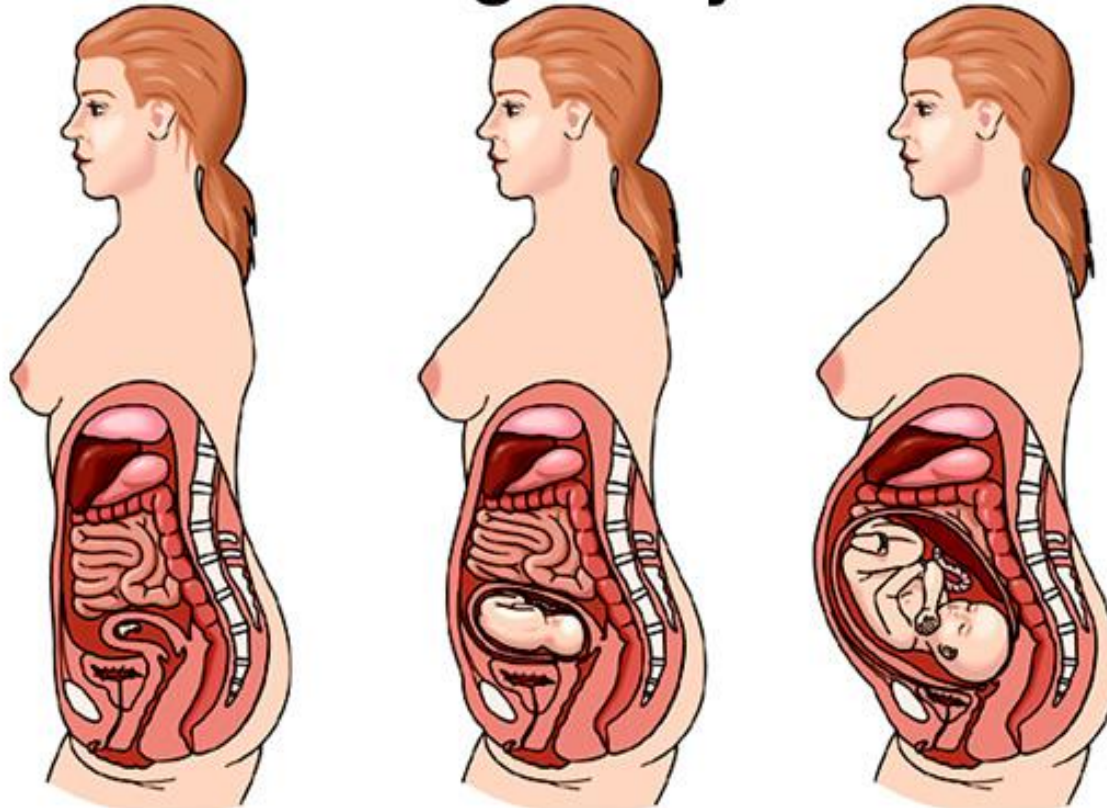
# Possible PFAS Human Effects



# Possible PFAS Human Effects

Byer/Shainberg/Galliano *Dimensions Of Human Sexuality*, 5e. Copyright © 1999. The McGraw-Hill Companies, Inc. All Rights Reserved.

## Changes in Woman's Body During Pregnancy



(a) First trimester (b) Second trimester (c) Third trimester

Fecundity

Hypertension  
In Pregnancy

Pre-eclampsia

Birth Weight

# C8 Study (PFOA,PFOS): 2004-6

## No “Probable Link” N=41

- HTN
- Coronary Heart Disease
- Stroke
- Chronic kidney disease
- Liver disease
- Osteoarthritis
- Parkinson’s disease
- Other autoimmune diseases (not UC)
- “Common infections” (i.e. influenza)
- Neurodevelopmental disorders, including ADHD and learning disabilities
- Asthma or COPD
- DM type 2
- Birth defects, miscarriage or stillbirths
- Preterm birth or low birth weight

## “Probable Link” N=6

- High cholesterol
- Thyroid disease
- Ulcerative colitis
- Testicular cancer
- Kidney cancer
- Pregnancy-induced hypertension

**Study of 69,030 participants from West Virginia and Ohio (Ohio-River Valley) exposed to PFOA from a Chemical Plant**



## C8 Science Panel

For six disease categories, the Science Panel concluded that there was a *Probable Link to C8 exposure* (although do not rise to a level of causation in a scientific study)

- High cholesterol (Nelson et al., 2010)
- Ulcerative colitis (Steenland, 2013),
- Thyroid disease (Melzer et al., 2010),
- Testicular cancer (Barry et al., 2013; Vieira et al., 2013),
- Kidney cancer (Barry et al., 2013; Vieira et al., 2013),
- Pregnancy induced hypertension (Stein et al., 2009; C8 Science Panel 2011)

# Cancer Studies

## No association – Prostate Cancer

- Eriksen, 2009
- Lundin, 2009
- Vieira, 2013
- Barry, 2013
- Raleigh, 2014
- Ducatman, 2015

## No association – Testicular Cancer

- Gilliland, 1993
- Leonard, 2008
- Lundin, 2009
- Steenland, 2012
- Vieira, 2013
- Gilliland, 1993

## No association – Kidney Cancer

- Leonard, 2008
- Lundin, 2009
- Raleigh, 2014

# Emerging Concerns

- **Poor response to childhood vaccine**

(Grandjean, 2012)

(Only tetanus and diphtheria antibodies were studied in a single study confounded by presence of PCBs and methyl mercury.)

- **Low Birth Weight**

(Fee et al., 2008)

[Estimated 15-19 gram (~0.03-0.04 lb.) reduction in birth weight for each 1  $\mu\text{g}/\text{L}$  increase in maternal PFOA blood level, and even smaller reductions for PFOS (Johnson et al. 2014; Verner et al. 2015).]





# Pediatric Studies

No association – ADHD, Autism, Milestones, IQ

- Fei, 2008
- Stein & Savitz - 2011
- Bellinger, 2013
- Liew, 2015

No LBW, Miscarriage or Birth Defects

- C8 Study - 2011

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# Case Study

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# Case

- 4-year-old boy in good health
- Mother worked at Pease Tradeport in Portsmouth, New Hampshire for 10 years and through pregnancy
- The boy attends daycare at Tradeport
- The mother heard that the water at Pease was contaminated with PFOA + PFOS + PFHxS for more than a decade
- The mother wants her child's blood tested for PFAS
- Should the health provider do it?

# Challenges

- Uncertainty
- Toxicology is complicated
- Balancing accuracy v. simplicity
- Misunderstanding, confusion, distrust
- Identifying values, perceptions, information needs
- Competing viewpoints



# Message Mapping

## What does this mean for my child's health?

- PFAS are toxic in experimental animals
- Further study required in humans
- Studies of potential health impacts on children have not yet shown definitive results

## What can I do to protect the health of my child?

- Since these chemicals are only measured experimentally, testing your child is not recommended
- Since there is no treatment to 'remove' PFAS from the body, efforts should focus on preventing further exposure
- Routine Well Child Care visits with your child's MD are recommended



# Case

## CHILD LABORATORY REPORT (< 12 years old)

Participant Name: [REDACTED]

Participant Identification Number: [REDACTED]

### Your Child's PFC Blood Test Results Compared with Children in the Schecter Study

PFC Tested	Your Child's Result (µg/L)	Schecter Study Results (µg/L)	
		Median	Range
PFOA perfluooctanoic acid	4.97	2.85	<0.1 - 13.50
PFOS perfluorooctane sulfonic acid	7.29	4.10	<0.2 - 93.30
PFHxS perfluorohexyl sulfonate	2.15	1.2	<0.1 - 31.20
PFUA perfluoroundecanoic acid	0.732	<i>Not reported in Schecter study</i>	<i>Not reported in Schecter study</i>
PFOSA perfluorooctane sulfonamide	0.6	<0.1	<0.1 - 0.60
PFNA perfluorononanoic acid	1.74	1.2	<0.1 - 55.80
PFDeA perfluorodecanoic acid	0.759	<0.2	<0.2 - 2.10
Me-PFOSA-AcOH <sub>2</sub> 2-(N-methyl-perfluorooctane sulfonamido) acetic acid	0.372	<0.2	<0.2 - 28.90
Et-PFOSA-AcOH 2-(N-ethyl-perfluorooctane sulfonamido) acetic acid	<0.1	<0.2	<0.2 - 0.70

(µg/L) = micrograms per liter

Median = middle PFC value of all 300 children tested

Note: A value reported as <0.1 or <0.2 indicates the result was less than the Limit of Detection (LOD) for that PFC by that testing method. Samples were analyzed at the National Center for Environmental Health, US Centers for Disease Control and Prevention, Chamblee, GA.

A health level concern has not been established for perfluorochemicals in blood.

# Citizen Inquiries

- Should my children be revaccinated?
- Should we be taking iodine?
- Should I breast feed my child?
- Will magnetic clay baths/detox patches help?
- Young mother: Will my baby require a liver transplant?
- Female adult: Will blood donation lower my PFAS levels faster?
- Male adult: Can herbs or cholestyramine lower the PFAS?
- 60 year old male: Did the water cause my erectile dysfunction?



# Case

- Mother provides child's blood tests with positive results for 9 different PFAS.
- She wants the child's blood tested for everything else that could be wrong with her.
- The mother is concerned about the child's thyroid, kidney, liver damage and overall immune system.
- Should the doctor order blood tests for these?



# Case

- Hgb 12.2 gm%
- Hct 33%
- MCV 74
- WBC 8600
- Diff: P18L76M4E1B1
- Retic 1.2%
- Na 134
- K 4.9
- Cl 110
- BUN 16
- Cr 0.6
- Fe 86
- Ferr 20
- T4 8.6
- AST 56
- ALT 16
- ESR 4

# Current Levels of Concern



# Current Levels of Concern

**PFAS in drinking water has been a growing issue in recent years.**

## January 2009

EPA's Office of Water established provisional health advisories to assess potential risk from short-term exposure via drinking water

- 0.2 µg/L for PFOS
- 0.4 µg/L for PFOA

## May 2012

As part of the Third Unregulated Contaminant Monitoring Rule, EPA required all community water systems serving >10,000 customers to monitor for PFCs twice in a 12-month period during 2013-2015

## August 2015

ATSDR released draft Toxicological Profile for PFAS

## May 2016

EPA issues Lifetime Health Advisory for PFOA and PFOS

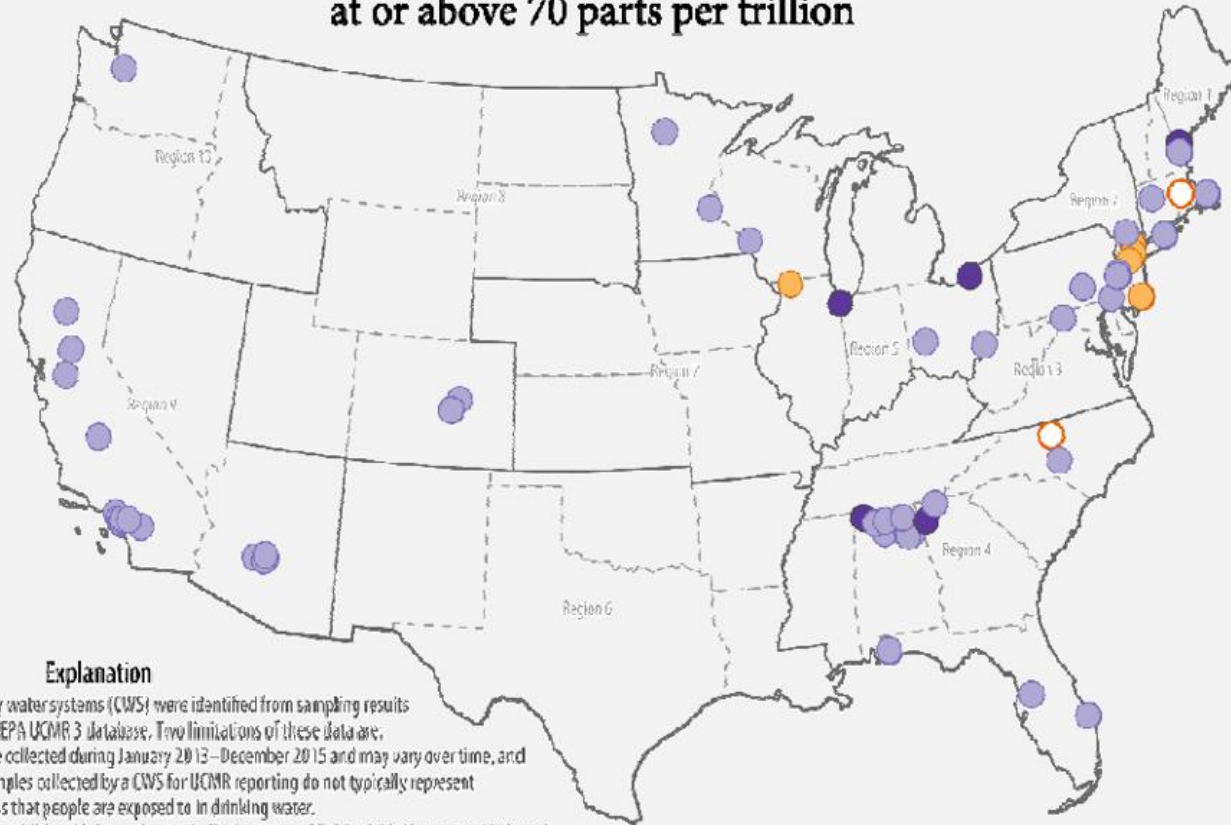
- 0.07 µg/L for PFOA
  - 0.07 µg/L for PFOS
- or
- 0.07 µg/L for PFOA+PFOS

## November 2016

NCEH and ATSDR continue to work together to investigate the relation between PFAS and human health and provide resources to communities

# National Scope

## Status of CWS (n=65) with UCMR3 reported levels of PFOS + PFOA (sum) at or above 70 parts per trillion



### Explanation

The 65 community water systems (CWS) were identified from sampling results reported in the USEPA UCMR3 database. Two limitations of these data are:

1. Samples were collected during January 2013–December 2015 and may vary over time, and
2. The water samples collected by a CWS for UCMR reporting do not typically represent concentrations that people are exposed to in drinking water.

ATSDR is gathering additional information to clarify the status of finished drinking water (delivered for public consumption) at each of these CWS. The results to date are rated as follows:

- Current and past levels less than 70 ppt (9 locations)
- Current levels less than 70; may have been past exceedences (53)
- Current levels at or above 70; CWS is taking actions to reduce (5)
- Current levels at or above 70; no CWS actions identified (0)
- Collecting information (2)

PFQA, perfluorooctanoic acid  
 PFOS, perfluorooctane sulfonic acid  
 CWS, Community water system  
 UCMR, Unregulated Contaminant Monitoring Rule  
 ppt, parts per trillion

Not shown

- Community water system (CWS) in Guam
- CWS in Saipan, Northern Mariana Islands

# Recommendations

- Perform routine diagnostic/screening tests based on a thorough history, physical exam, and assessment
- No specific testing or screening is recommended based on PFAS levels
- Cannot connect specific health problems to PFAS
- Repeat PFAS testing not medically indicated
- No specific therapies: not iodine, not vitamin C, not cholestyramine, not revaccination, not phlebotomy
- ATSDR recommends: reduce future PFAS exposure

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# Reducing Exposures

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# Advice for Patients: Exposure Reduction

## Drinking water: filters

- Point of use, point of entry



<https://www.pbs.org/newshour/science/pfas-toxic-chemical-millions-peoples-drinking-water>

# Fish Advisories

territories and tribes to also issue safe eating guidelines to let people know what fish they can eat safely and to encourage consumption of fish and shellfish as part of a healthy diet.

## Advisories: What Not to Eat?

A consumption advisory is a recommendation to limit or avoid eating certain species of fish or shellfish caught from specific water bodies or types of water bodies (e.g., lakes, rivers or coastal waters) due to chemical contamination.

Advisories may be issued for the general public or for specific groups of people at risk, such as:

- High consumers of fish
- The elderly
- Pregnant women
- Nursing mothers
- Children

An advisory about fish from a specific waterbody or type of waterbody may address more than one affected fish species or chemical contaminant.

## National Listing of Fish Advisories

EPA maintains a national database of fish and shellfish advisories issued by states.

- [General Fact Sheet](#)
- [Technical Fact Sheet](#)
- [Questions and Answers](#)
- [National Maps and Graphics](#)
- [Search for Advisories Where You Live](#)

Advisories

Safe Eating Guidelines

Contaminants



<https://www.epa.gov/choose-fish-and-shellfish-wisely/fish-and-shellfish-advisories-and-safe-eating-guidelines>



# Advice for Patients: Exposure Reduction

- Reduce use of consumer products containing PFAS
- Frequent dusting with damp mop, damp wipe

# Responding to Patient Concerns

- Listen to patient's concerns
- Perform thorough medical history and physical exam including history of exposure
- Routine cholesterol screening, including children
- Blood testing for PFAS:
  - “There is currently no established PFAS blood level at which a health effect is known to occur.”
  - “PFAS blood levels can only show how you compare to the rest of the population.”

ATSDR 2017. Interim Guidance.

[https://www.atsdr.cdc.gov/pfc/docs/pfas\\_clinician\\_fact\\_sheet\\_508.pdf](https://www.atsdr.cdc.gov/pfc/docs/pfas_clinician_fact_sheet_508.pdf)

# Responding to Patient Concerns

- Reassure that any unusual symptoms will be addressed
- “The benefits of breastfeeding your baby outweigh those of not breastfeeding.”
- “There are no recommendations for repeating vaccinations.”

ATSDR 2017. Interim Guidance.

[https://www.atsdr.cdc.gov/pfc/docs/pfas\\_clinician\\_fact\\_sheet\\_508.pdf](https://www.atsdr.cdc.gov/pfc/docs/pfas_clinician_fact_sheet_508.pdf)

# Resources on PFAS chemicals

## Visit the following websites:

- » ATSDR website:  
<http://www.atsdr.cdc.gov/pfc/index.html>
- » ATSDR's PFAS Factsheets:  
[https://www.atsdr.cdc.gov/pfc/docs/pfas\\_clinician\\_fact\\_sheet\\_508.pdf](https://www.atsdr.cdc.gov/pfc/docs/pfas_clinician_fact_sheet_508.pdf)
- [https://www.atsdr.cdc.gov/pfas/docs/pfas\\_fact\\_sheet.pdf](https://www.atsdr.cdc.gov/pfas/docs/pfas_fact_sheet.pdf)
- [https://www.atsdr.cdc.gov/pfas/docs/PFAS\\_in\\_People.pdf](https://www.atsdr.cdc.gov/pfas/docs/PFAS_in_People.pdf)
- [https://www.atsdr.cdc.gov/pfas/docs/Talking\\_to\\_Doctor.pdf](https://www.atsdr.cdc.gov/pfas/docs/Talking_to_Doctor.pdf)
- » Environmental Protection Agency website:  
<https://www.epa.gov/chemical-research/research-and-polyfluoroalkyl-substances-pfas>

# Visuals Acknowledgements and Sources

Slide #6, #13, #35, #36 : CDC, Permission P. Breysse

Slide #9

- Img.1: Northwestpaddlingassociationfestical.com (fabric with water);
- Img.2: Wikipedia (Teflon frying pan);
- Img.3: mountainviewcarpetcare.com (wine on carpet);
- Img.4: Firefightingprotection.com;
- Img.5: Starwarfare.wikia.com (French fries)

Slide #10: Img. Source: Purchased iStock

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<https://www.sciencedirect.com/science/article/pii/S0045653512004626?via%3Dihub>

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Slide #40: Source: <https://www.epa.gov/choose-fish-and-shellfish-wisely/fish-and-shellfish-advisories-and-safe-eating-guidelines>

**Thank you!**