

Per- and polyfluoroalkyl substances (PFAS)
(also known as perfluorochemicals, PFCs)

Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA)

What are PFAS?

- Per- and polyfluoroalkyl substances (PFAS), previously referred to as perfluorochemicals (PFCs), are human-made chemicals that do not occur naturally in the environment. The chemical structure of PFAS have a fluorinated carbon chain, either partially or fully fluorinated, connected to different functional groups.
- Currently, there are thousands of chemicals that are considered PFAS.
- PFAS have been widely used in consumer, commercial, and industrial products since the 1950s.
- Many PFAS break down very slowly in the environment.

What are PFOS and PFOA?

- Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are two chemicals in the PFAS family. They are also human-made chemicals that do not occur naturally in the environment.
- These two PFAS were produced in the largest amounts in the U.S. and are commonly found in our environment.
- PFOS and PFOA can also be formed by environmental microbial degradation or by metabolism in larger organisms from a large group of related chemicals or precursor compounds.
- Companies have stopped production or have begun changing manufacturing practices to reduce releases and to reduce the amounts of PFOA and PFOS chemicals in their products.

What are the uses of PFOS and PFOA?

- PFOS and PFOA have been used in surface protection products, such as carpet, clothing,

and cookware (Teflon®, Nonstick) treatments, and coating for paper, furniture and some food packaging materials (e.g., microwave popcorn bags, fast food containers, candy wrapper and pizza boxes), and personal products like shampoo, dental floss, nail polish, eye makeup, etc.

- Industrial uses of these chemicals are in photo imaging, metal plating, semiconductor coatings, aviation hydraulic fluids, medical devices, insect baits, printer and copy machine parts, chemically driven oil production, rubber and plastic industries.
- Both chemicals have also been present in some foam firefighting materials.

What are the environmental impacts of PFOS and PFOA?

- PFOS and PFOA can be found in air, soil, and water (ground and surface water) after release from the manufacture, use, and disposal of products that contain these chemicals.
- PFAS (including PFOS and PFOA) in air are expected to settle to the ground within days to weeks.
- They breakdown very slowly in the environment and are often characterized as persistent.

How are people exposed to PFOS and PFOA?

- Exposure to PFOS, PFOA and other PFAS like perfluorononanoic acid (PFNA), and perfluorohexane sulfonic acid (PFHxS) are widespread and have been detected in blood samples of the general U.S. population and wildlife. These chemicals have been detected in 95-100% of samples of people's blood in the years 1999-2000 and 2003-2004. Recent monitoring data show the levels of these chemicals in people's blood appear to be declining. From 1999-2000 to 2017-2018, blood PFOS and PFOA have declined by more than 85% and 70%, respectively. Based on the recent [National Health and Nutrition Examination Survey data \(2017-2018\)](#) the geometric mean of serum levels for the total population are as follows:
 - PFOA: 1.42 ppb (95% of the general population at or below 3.77 ppb)
 - PFOS: 4.25 ppb (95% of the general population at or below 14.6 ppb)
 - PFHxS: 1.08 ppb (95% of the general population at or below 3.70 ppb)(ppb - parts per billion; 1 ppb = 1 µg/L)
- People may be exposed to PFOS and PFOA from the air, indoor dust, water, food and numerous consumer products. Also, people may be exposed to these chemicals from

treated carpets and upholstery; this is especially true for children.

- Food is anticipated to be a source of exposure to these chemicals. Environmental contamination or through migration from food packaging are two pathways for PFAS to enter the food chain.
- Since PFAS have been detected in human breast milk, infants may be exposed to these chemicals through breast milk.
- Workers in the perfluorochemical industry can be exposed to greater amounts of PFOS and PFOA than in general population.

How can PFOS and PFOA enter and leave the body?

- PFOS, PFOA and other PFAS can enter your body if you breathe air, eat food or drink water containing them. It is not known how much will enter your body through your lungs or your gut.
- Also, if PFAS come in contact with skin, it is possible that a small amount may enter the body through your skin.
- PFAS tend to remain unchanged in the body for long periods of time. PFOA and PFOS stay in the body for many years. It takes nearly four years for the level in the body to go down by half. PFAS leave the body mainly through urine.

How can PFOS and PFOA affect people's health?

- The human health effects from exposure to low environmental levels of PFOS and PFOA are not known.
- There are some human epidemiological studies that suggest that a possible relationship between exposure to PFAS and health effects, but other studies do not show a correlation between exposure to PFAS and health effects. Because of the contradictory findings, more research is needed to understand the health effects of exposure to PFAS on humans.
- Some of the available studies suggest that increase in blood cholesterol levels are associated with higher PFOS and PFOA blood levels.
- There is some indication that serum PFOS and PFOA may be associated with increased uric acid levels, which may be associated with an increased risk of high blood pressure.

- PFOA and PFOS may be associated with pregnancy-induced hypertension/pre-eclampsia. PFAS may also be associated with a decrease infant and fetal growth.
- Human epidemiologic studies have shown PFOA, PFOS, and PFHxS may be associated with increased serum liver enzymes, such as alanine aminotransferase (ALT), and decreases in serum bilirubin levels.
- PFOA and PFOS have been associated with decreased antibody response to vaccines in children.
- Exposure to PFOS and PFOA may cause liver damage. Studies in mice found that the immune system is a sensitive target for PFOS and PFOA; health effects include decreases in the size of the spleen, thymus and impaired immune system. The ingestion of PFOA contaminated water was found to cause adverse health effects on mammary gland development in mice. Also, oral studies on rodents have raised concerns about potential developmental, reproductive, and other systematic effects of PFOA and PFOS.
- Humans and rodents react differently to PFOA and PFOS and not all of the effects observed in rats and mice may occur in humans. The liver appears to be the most sensitive target in animals ingesting PFAS. The health effects include increases in liver weight, changes in liver cells, change in blood cholesterol, and triglycerides levels.

Are PFOS and PFOA likely to cause cancer?

- The International Agency for Research on Cancer has concluded that PFOA is *possibly carcinogenic to humans* (Group 2B) based on *limited evidence* in humans and *limited evidence* in experimental animals as to the carcinogenicity of PFOA.
- The U.S. Environmental Protection Agency (U.S. EPA) concluded that there was suggestive evidence of carcinogenic potential of PFOA and PFOS in humans.
- Currently, there is no consistent scientific evidence that PFOS and PFOA cause cancer in humans. Some increases in kidney and testicular cancers have been seen in highly exposed individuals, mostly occupational exposures. These results should be interpreted carefully since the effects were not found consistently across studies, there were contradictory findings between studies, and exposure levels were much higher than generally seen in the general population.

How are children more susceptible to potential exposures from PFOS and PFOA?

- Carpets treated with PFOS and PFOA can be an important source of exposure for children, because of hand-to-mouth exposure from environmental sources (carpets,

dust, etc.). Children also can be exposed to higher doses of PFOS and PFOA for their body weight than an adult.

- It can also pass to a nursing infant through breast milk since these chemicals have been detected in human breast milk.
- Possible effects in children include changes in growth, learning, decreased antibody response to vaccines, and behavior
- Health effects observed in children are similar to adults. A study of children exposed to high levels of PFOA in drinking water found increases in blood cholesterol.
- Some studies of the general population and people living near a PFOA manufacturing facility have found that higher levels of serum PFOA or PFOS are associated with lower infant birth weights.
- Based on animal studies, oral exposure to PFOA and PFOS has resulted in early death and delayed development of pups (mouse and rat). Also, alterations in motor activity have been observed pups (mouse) exposed to PFOA and PFOS. Scientists believe that some of the effects observed in animals exposed to PFOA and PFOS may not be relevant to humans. Further, most adverse health effects in animal studies have been associated with exposures that resulted in blood levels of PFAS that were significantly higher than those observed in PFAS workers or the general population.
- Currently, no associations between serum PFOA and birth defects were observed in children of mothers living in an area with high PFOA levels in the water, although more study is needed.

How can people reduce the risk of exposure to PFOS and PFOA?

- People may choose to use consumer products that do not contain PFOS, PFOA, and other PFAS.
- People whose well water contains these chemicals above U.S. EPA's drinking water advisory levels, may choose to install an activated carbon filtration system or reverse osmosis system.
- U.S. Food and Drug Administration (FDA) has not established standards for PFAS contaminants in bottled water. Therefore, U.S. EPA does not currently support bottled water use for communities based solely on concentrations of PFAS in drinking water that exceed recent (2022) U.S. EPA health advisory levels.

Is there a medical test to determine whether a person has been exposed to PFOS and PFOA?

- PFOS and PFOA as well as other PFAS can be measured in blood. The presence of these chemicals in your blood may indicate that you have been exposed to these chemicals. PFOA and PFOS have been measured in blood samples in 2017-2018 from a representative sample of the U.S. population; the geometric mean serum of PFOA and PFOS concentrations were 1.42 µg/L and 4.25 µg/L, respectively.
- Analysis of PFAS chemicals is not included in routine blood testing. If you suspect you have been exposed to elevated levels of PFAS, consult with your physician or healthcare provider for guidance on testing. The National Academies of Sciences, Engineering, and Medicine (NASEM) released a [guidance document](#) for PFAS exposure, testing, and clinical follow-up in July 2022. According to NASEM guidance, PFAS levels in blood ranging from 2 – <20 µg/L or ≥20 µg/L, suggest reducing potential sources of PFAS exposure and may indicate additional health screening or assessment for other health effects such as dyslipidemia, hypertensive disorders, thyroid function, kidney or testicular cancer, and/or ulcerative colitis. It should be noted that PFAS levels found in blood do not predict what health effects might occur.

Has the federal government made recommendations to protect human health?

- In 2016, to provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOA and PFOS in drinking water, U.S. EPA established the health advisory levels at 70 parts per trillion (ppt) or 0.07 µg/L.
- In 2022, U.S. EPA replaced the 2016 advisories with updated *interim* lifetime health advisories for **PFOA and PFOS of 0.004 ppt and 0.02 ppt, respectively**. U.S. EPA also established lifetime health advisories for perfluorobutane sulfonic acid and related compound potassium perfluorobutane sulfonate, together referred to as “PFBS” of 2,000 ppt and hexafluoropropylene oxide (HFPO) dimer acid and its ammonium salt, together referred to as “GenX chemicals” of 10 ppt.
 - These health advisories were updated by U.S. EPA in 2022 based on new studies. This health advisory level offers a margin of protection for all Americans throughout their life from adverse health effects resulting from exposure to PFOA and PFOS in drinking water. The critical health effect the *interim* health advisories for PFOA and PFOS were based on are decreased antibody response in children to tetanus and diphtheria vaccination, respectively.
- The updated interim health advisories for PFOA and PFOS are far below current analytical method detection limits. The detection limit is defined as “the minimum concentration of an analyte (substance) that can be measured and reported with a 99%

confidence that the analyte concentration is distinguishable from the method blank results” (40 CFR Part 136). Reported [detection limits](#) for PFOA and PFOS are 0.5 and 1.1 ppt, respectively, using the EPA PFAS method 537.1, but may vary by laboratory and analytical instrument. While it is possible to have PFOA or PFOS in drinking water below the limit of detection but above the new interim health advisories, we know that the lower the levels of PFOA and PFOS, the lower the health risk.

- The Occupational Safety and Health Administration (OSHA) has not set any legal limits for PFAS including PFOA and PFOS in air.
- The National Institute of Occupational Safety and Health (NIOSH) has not set any recommended limits including PFOA and PFOS in air.

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