PUBLIC HEALTH STATEMENT
Perfluoroalkyls

Division of Toxicology and Human Health Sciences **August 2015**

This Public Health Statement summarizes the Division of Toxicology and Human Health Science's findings on perfluoroalkyls, tells you about them, the effects of exposure, and describes what you can do to limit that exposure.

The U.S. Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are sites targeted for long-term federal clean-up activities. Perfluoroalkyls have not been reported at EPA NPL sites; however, it is unknown how many of the 1,699 current or former NPL sites have been evaluated for the presence of perfluoroalkyls. As more sites are evaluated, the sites at which perfluoroalkyls is found may increase. This information is important because these future sites may be sources of exposure, and exposure to perfluoroalkyls may be harmful.

If you are exposed to perfluoroalkyls, many factors determine whether you'll be harmed. These include how much you are exposed to (dose), how long you are exposed to it (duration), and how you are exposed (route of exposure). You must also consider the other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

WHAT ARE PERFLUOROALKYLS?

Perfluoroalkyls are a family of human-made chemicals that do not occur naturally in the environment. Thirteen perfluoroalkyl compounds are discussed in this profile. The names of these perfluoroalkyls are as follows: perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorododecanoic acid (PFDoA), perfluorodecanoic acid (PFDeA), perfluorobutyric acid (PFBA), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), perfluoroundecanoic acid (PFUA), perfluorohexane sulfonic acid (PFHxS), perfluorobutane sulfonic acid (PFBuS), perfluorooctane sulfonamide (PFOSA), 2-(N-methyl-perfluorooctane sulfonamide) acetic acid (Me-PFOSA-AcOH), and 2-(N-ethyl-perfluorooctane sulfonamide) acetic acid (Et-PFOSA-AcOH).

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Perfluoroalkyls are unique because they repel oil, grease, and water. They have been used in surface protection products such as carpet and clothing treatments and coatings for paper and cardboard packaging. Some perfluoroalkyls have also been used in fire-fighting foams.

WHERE ARE PERFLUOROALKYLS FOUND?

Perfluoroalkyls can be released into the air, water, and soil at places where they are produced or used. Perfluoroalkyls were made in large amounts in the United States. PFOA and PFOS are the two perfluoroalkyl compounds made in the largest amounts. Companies have stopped production or have begun changing manufacturing practices to reduce releases and the amounts of these chemicals in their products. Some facilities are replacing many of the perfluoroalkyls with other substances.

Perfluoroalkyls have been found in both air and dust; surface water and groundwater; and soil and sediment. The highest levels of perfluoroalkyls in the environment are typically found near facilities that have made or used these substances. However, they have also been found at remote locations such as the Arctic and the open ocean. They may be subject to long-range transport. Perfluoroalkyls are very stable compounds and are resistant to being broken down in the environment. Perfluoroalkyls in the air are expected to settle to the ground within days to weeks. Perfluoroalkyls may be carried through soil by groundwater and flooding and become airborne during windy conditions.

HOW MIGHT I BE EXPOSED TO PERFLUOROALKYLS?

Exposure to perfluoroalkyl compounds is widespread. PFOA, PFOS, PFNA, and PFHxS were detected in 95–100% of samples of people's blood in 1999–2000 and 2003–2004. More recent monitoring data still show widespread exposure; however, the levels of these substances in people's blood appear to be declining. You may be exposed to perfluoroalkyls from the air, indoor dust, food, water, and various consumer products. Food is expected to be the primary source of exposure to perfluoroalkyls such as PFOA and PFOS for most people. Some communities near facilities where PFOA and PFOS were previously manufactured had high levels of these substances in drinking water supplies, and this is the primary route of exposure for these populations. Limited information has been located regarding

pathways of human exposure to most of the other perfluoroalkyls discussed in this toxicological profile. Human breast milk may contribute to the exposure of infants to perfluoroalkyls since these substances have been detected in human breast milk. You may also be exposed to perfluoroalkyls from treated carpets and upholstery; this is especially true for children. The greatest source of exposure to PFOA and PFOS for toddlers and children is hand-to-mouth activities from treated carpets.

People who work where perfluoroalkyls are made or used are exposed to higher levels of these substances than the general population. Levels of PFOS and PFOA measured in the blood of some people who have worked at these locations were higher than levels in people from the same communities who did not work at these locations. Workplace exposure also occurred for people with jobs that required frequent handling or use of perfluoroalkyl-treated substances, such as carpet installers. At sites where aqueous film-forming foam (AFFF) that contained perfluoroalkyl substances was used in firefighting, workers could be exposed to these substances and possibly transport them home from contaminated clothing.

HOW CAN PERFLUOROALKYLS ENTER AND LEAVE MY BODY?

Perfluoroalkyls can enter your body if you breathe air, eat food, or drink water containing them. We do not know how much will enter your body through your lungs or your digestive tract. If your skin comes into contact with dusts or aerosols of perfluoroalkyl or with liquids containing perfluoroalkyls, it is possible that a small amount may enter the body through your skin.

Once in your body, perfluoroalkyls tend to remain unchanged for long periods of time. The most commonly used perfluoroalkyls (PFOA and PFOS) stay in the body for many years. It takes approximately 4 years for the level in the body to go down by half, even if no more is taken in. It appears that, in general, the shorter the carbon-chain length, the faster the perfluoroalkyl leaves the body. Perfluoroalkyls leave the body primarily in the urine.

HOW PERFLUOROALKYLS CAN AFFECT YOUR HEALTH?

A large number of studies have examined the possible health effects of PFOA and PFOS in humans. The effect of inhalation exposure to PFOA and PFOS has been examined in workers exposed to high concentrations of these compounds. Studies have also examined a large community exposed to high levels of PFOA in the drinking water and compared this community to the general population; ingestion was the primary route of exposure for these two groups. Most human studies have looked for a relationship between levels of perfluoroalkyls in the blood and a health effect. It is difficult to interpret the results of these studies because they are not consistent; some studies have found associations, but others looking at the same health effect have not found these associations. Even though some studies have found significant associations between serum perfluoroalkyl levels and adverse health effects, it does not mean that perfluoroalkyls caused these effects. The effects may have been due to other factors that were not considered by the researchers. The available studies suggest that increases in blood cholesterol levels are associated with higher PFOA or PFOS blood levels in workers inhaling PFOA and/or PFOS as well as in people ingesting these compounds. There are data to suggest an association between serum PFOA and PFOS levels and increased uric acid levels, which may be associated with an increased risk for high blood pressure. There is also some evidence that PFOA and PFOS exposure may cause liver damage.

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 perfluoroalkyls. The effects include increases in liver weight, changes in the liver cells, and changes in blood cholesterol and triglyceride levels. Studies in mice also found that the immune system is a sensitive target of PFOA and PFOS; effects include decreases in the size of the spleen and thymus and impaired immune function.

A short exposure of rats to very high levels of PFOA in the air caused irritation of the eyes and nose. Damage to the liver and weight loss were observed in rats exposed to lower levels of PFOA in the air.

Short-term application of large amounts of PFOA to the skin of animals has caused skin irritation and changes in the liver. These liver effects indicate that PFOA can be absorbed into the body through the skin and affect other parts of the body.

There is limited information on whether perfluoroalkyls can cause cancer in humans. Some increases in prostate, kidney, and testicular cancers have been found in workers or in community members living near a PFOA facility. These results should be interpreted cautiously because the effects were not consistently found and most studies did not control for other potential factors such as smoking. Feeding PFOA and PFOS to rats caused them to develop tumors. Some scientists believe that, based on the way this happens in rats and the differences between rats and humans, humans would not be expected to get cancer. Others believe that it is possible for perfluoroalkyls to cause cancer in humans, and the studies in rats should not be dismissed. More research is needed to clarify this issue. The International Agency for Research on Cancer and the Department of Health and Human Services have not yet evaluated the carcinogenicity of perfluoroalkyls. The EPA has begun an evaluation.

HOW CAN PERFLUOROALKYLS AFFECT CHILDREN?

This section discusses potential health effects of perfluoroalkyls exposure in humans from when they're first conceived to 18 years of age, and how you might protect against such effects.

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. 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. However, the decrease in birth weight is small and may not affect the infant's health. A study in children exposed to high levels of PFOA in drinking water found increases in blood cholesterol, which was similar to the findings in adults.

Birth defects were seen in mice born to females that ingested relatively high amounts of PFOS during pregnancy. The blood PFOS levels associated with these effects were at least 10 times higher than the highest PFOS levels measured in workers. Oral exposure to PFOA and PFOS has resulted in early death

and delayed development of mouse and rat pups, but this did not occur in animals exposed to PFBA or PFHxS. Alterations in motor activity have also been observed in mouse pups exposed to PFOA, PFOS, or PFHxS, but not PFDeA. Scientists believe that some of the effects observed in rats and mice exposed to PFOA or PFOS may not be relevant to humans.

HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO PERFLUOROALKYLS?

If your doctor finds that you have been exposed to significant amounts of perfluoroalkyls, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

In the past, some perfluoroalkyls such as PFOA and PFOS were used in the manufacture of many consumer products, and low levels of these substances were detected in things such as treated carpeting, treated apparel, and paper food packaging. Companies are no longer using PFOA in the manufacture of Teflon coatings or PFOS in the manufacture of stain resistant carpet treatments; however, older products and imported materials may still contain these substances. Families may choose to use products that do not contain pre-treated stain repellent products or grease resistant food packaging. Families that have been told that their tap or well water contains high levels of perfluoroalkyls may choose to drink or cook with bottled water or to install activated carbon water filters in their drinking water system. Consuming bottled water and the use of activated carbon water filters have been shown to lead to lower PFOA levels in the blood over time by decreasing exposure to perfluoroalkyl compounds.

ARE THERE MEDICAL TESTS TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO PERFLUOROALKYLS?

Perfluoroalkyl compounds can be measured in blood, but this is not a routine test that can be performed in a doctor's office. You should, however, see a physician if you believe that you have been exposed to high levels of perfluoroalkyls. Perfluoroalkyls have been measured in blood samples in 2009–2010 from a representative sample of the U.S. general population; the geometric mean serum PFOA and PFOS concentrations were 3.07 and 9.32 µg/L, respectively. Elevated serum PFOA levels were reported in

Mid-Ohio Valley residents who had environmental exposure to PFOA from drinking water contaminated by a nearby industrial facility. The range of median serum PFOA levels across several communities was 12.1–224.1 ng/mL and the mean serum PFOA concentration across all of the communities was 83.6 µg/L in 2005. Higher serum perfluoroalkyl concentrations have been reported in fluorochemical product workers. Mean serum PFOA and PFOS levels for at one facility were 1,780 and 1,320 µg/L, respectively. Workers at another facility had serum PFOA levels of 1,000 µg/L.

WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed as “not-to-exceed” levels; that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value usually based on levels that affect animals; levels are then adjusted to help protect humans. Sometimes these not-to-exceed levels differ among federal organizations. Different organizations use different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or emphasize some factors over others, depending on their mission.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that issued the regulation or recommendation.

The EPA has recommended provisional drinking water health advisories of 0.4 µg/L for PFOA and 0.2 µg/L for PFOS. OSHA has not set any legal limits for perfluoroalkyl compounds in air. NIOSH has not set any recommended limits for perfluoroalkyl compounds in air.

WHERE CAN I GET MORE INFORMATION?

If you have any questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below. ATSDR can also provide publically available information regarding medical specialists with expertise and experience recognizing, evaluating, treating, and managing patients exposed to hazardous substances.

- Call the toll-free information and technical assistance number at 1-800-CDCINFO (1-800-232-4636) or

- Write to:
  Agency for Toxic Substances and Disease Registry
  Division of Toxicology and Human Health Sciences
  1600 Clifton Road NE
  Mailstop F-57
  Atlanta, GA 30329-4027

Toxicological profiles and other information are available on ATSDR's web site: http://www.atsdr.cdc.gov.