

PFAS and Developmental and Reproductive Toxicity:



AN EWG FACT SHEET

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The toxic fluorinated chemicals known as PFAS are a class of environmentally persistent manmade chemicals that are used as water, grease and stain repellents in clothing and furniture, in industrial firefighting foam, and in the production of nonstick cookware.

PFAS, which are detected in the blood of nearly every American, are associated with multiple adverse health effects, including immunotoxicity, cancer and increased cholesterol, as well as developmental and reproductive toxicity.

Exposure can occur through food, water, indoor air and consumer products. PFAS chemicals readily cross through the placenta and have been detected in cord blood, indicating direct exposure to the developing fetus. PFAS are also detected in breast milk, which provides another exposure route for infants.

Such exposures can lead to developmental and reproductive toxicity from PFAS, including low birth weight, thyroid disruption, harm to the male reproductive system, pregnancy-induced hypertension, and some evidence of shorter duration of breastfeeding and infertility. The Environmental Protection Agency’s health advisory values for the two best-known PFAS chemicals—PFOA, formerly used to make DuPont’s Teflon, and PFOS, formerly an ingredient in 3M’s Scotchgard—set in 2016, are based on developmental toxicity.

DEVELOPMENTAL AND REPRODUCTIVE HEALTH EFFECTS ASSOCIATED WITH EXPOSURE TO PFAS

ADVERSE HEALTH EFFECTS RELEVANT FOR HUMANS	EVIDENCE FROM HUMAN AND ANIMAL STUDIES
Low birth weight	<ul style="list-style-type: none"> • PFOA levels in maternal serum during pregnancy are associated with lower birth weight.¹ • Evidence of reduced fetal weight has also been observed in animal studies.²
Thyroid disruption	<ul style="list-style-type: none"> • Studies in humans find associations among PFAS, PFHxS and PFOS; exposure during pregnancy; and increases in maternal thyroid stimulating hormone, or TSH.³ • Animal studies on PFOA, PFOS, PFBA, PFBS, PFHxA, PFHxS, PFNA, and PFDA cause changes in thyroid hormone levels, TSH and thyroxine, or T4, in adult animals.^{4,5}
Harm to sperm and the male reproductive system	<ul style="list-style-type: none"> • In humans, maternal exposure to PFOA was associated with reduced sperm concentrations and count in male offspring.⁶ • Men living in a region of Italy highly contaminated by PFOA had reduced semen quality, testicular volume and penile length compared to controls.⁷ • Animals studies find decreases in serum testosterone and sperm count from developmental and adult exposure to PFOA.^{8,9}
Pregnancy induced hypertension (preeclampsia)	<ul style="list-style-type: none"> • Evidence from the C8 Health Study of 70,000 residents near a DuPont Teflon plant in West Virginia suggests a probable link between PFOA and PFOS and pregnancy-induced hypertension.^{10,11,12} • Other studies have found no association.^{13,14}

ADVERSE HEALTH EFFECTS RELEVANT FOR HUMANS

EVIDENCE FROM HUMAN AND ANIMAL STUDIES

<p>Reduced time of breastfeeding and impacts on mammary gland development</p>	<ul style="list-style-type: none"> • Some human studies have reported PFOA and PFOS exposure to be associated with shorter durations of breastfeeding.^{15,16} • Animal studies find PFOA causes reduced mammary gland development in females and offspring, although impacts on lactation and/or nursing behavior have not been well assessed.^{17,18,19}
<p>Increased time to pregnancy</p>	<ul style="list-style-type: none"> • In human studies, PFOA and PFOS exposure has been associated with longer time to pregnancy, an indicator of infertility or subfecundity.^{20,21} • Other studies find no association.^{22,23,24,25}

References

1. Johnson, P.I., et al., *The Navigation Guide—evidence-based medicine meets environmental health: systematic review of human evidence for PFOA effects on fetal growth*. Environ Health Perspect, 2014. **122**(10): p. 1028-39.
2. Koustas, E., et al., *The Navigation Guide—evidence-based medicine meets environmental health: systematic review of nonhuman evidence for PFOA effects on fetal growth*. Environ Health Perspect, 2014. **122**(10): p. 1015-27.
3. Ballesteros, V., et al., *Exposure to perfluoroalkyl substances and thyroid function in pregnant women and children: A systematic review of epidemiologic studies*. Environ Int, 2017. **99**: p. 15-28.
4. NTP, *NTP technical report on the toxicity studies of perfluoroalkyl sulfonates (perfluorobutane sulfonic acid, perfluorohexane sulfonate potassium salt, and perfluorooctane sulfonic acid) administered by gavage to Sprague Dawley (Hsd:Sprague Dawley SD) rats*. Research Triangle Park, NC, 2019. **National Toxicology Program. Toxicity Report 96**.
5. NTP, *NTP technical report on the toxicity studies of perfluoroalkyl carboxylates (perfluorohexanoic acid, perfluorooctanoic acid, perfluorononanoic acid, and perfluorodecanoic acid) administered by gavage to Sprague Dawley (Hsd:Sprague Dawley SD) rats*. Research Triangle Park, NC, 2019. **National Toxicology Program. Toxicity Report 97**.
6. Vested, A., et al., *Associations of in utero exposure to perfluorinated alkyl acids with human semen quality and reproductive hormones in adult men*. Environ Health Perspect, 2013. **121**(4): p. 453-8.
7. Di Nisio, A., et al., *Endocrine Disruption of Androgenic Activity by Perfluoroalkyl Substances: Clinical and Experimental Evidence*. J Clin Endocrinol Metab, 2019. **104**(4): p. 1259-1271.
8. Lau, C., et al., *Perfluoroalkyl acids: a review of monitoring and toxicological findings*. Toxicol Sci, 2007. **99**(2): p. 366-94.
9. Song, P., et al., *Effects of perfluorooctanoic acid exposure during pregnancy on the reproduction and development of male offspring mice*. Andrologia, 2018. **50**(8): p. e13059.
10. Stein, C.R., D.A. Savitz, and M. Dougan, *Serum levels of perfluorooctanoic acid and perfluorooctane sulfonate and pregnancy outcome*. Am J Epidemiol, 2009. **170**(7): p. 837-46.
11. Darrow, L.A., C.R. Stein, and K. Steenland, *Serum perfluorooctanoic acid and perfluorooctane sulfonate concentrations in relation to birth outcomes in the Mid-Ohio Valley, 2005-2010*. Environ Health Perspect, 2013. **121**(10): p. 1207-13.
12. Savitz, D.A., et al., *Perfluorooctanoic acid exposure and pregnancy outcome in a highly exposed community*. Epidemiology, 2012. **23**(3): p. 386-92.
13. Starling, A.P., et al., *Perfluoroalkyl substances during pregnancy and validated preeclampsia among nulliparous women in the Norwegian Mother and Child Cohort Study*. Am J Epidemiol, 2014. **179**(7): p. 824-33.
14. Savitz, D.A., et al., *Relationship of perfluorooctanoic acid exposure to pregnancy outcome based on birth records in the mid-Ohio Valley*. Environ Health Perspect, 2012. **120**(8): p. 1201-7.
15. Timmermann, C.A.G., et al., *Shorter duration of breastfeeding at elevated exposures to perfluoroalkyl substances*. Reprod Toxicol, 2017. **68**: p. 164-170.
16. Romano, M.E., et al., *Maternal serum perfluoroalkyl substances during pregnancy and duration of breastfeeding*. Environ Res, 2016. **149**: p. 239-246.
17. Post, G.G., J.A., *TECHNICAL SUPPORT DOCUMENT: INTERIM SPECIFIC GROUND WATER CRITERION FOR PERFLUOROOCCTANOIC ACID (PFOA, C8) (CAS #: 335-67-1; Chemical Structure: CF3(CF2)6COOH)*. Division of Science and Research, New Jersey Department of Environmental Protection, 2019.
18. White, S.S., et al., *Gestational PFOA exposure of mice is associated with altered mammary gland development in dams and female offspring*. Toxicol Sci, 2007. **96**(1): p. 133-44.
19. Tucker, D.K., et al., *The mammary gland is a sensitive pubertal target in CD-1 and C57Bl/6 mice following perinatal perfluorooctanoic acid (PFOA) exposure*. Reprod Toxicol, 2015. **54**: p. 26-36.
20. Fei, C., et al., *Maternal levels of perfluorinated chemicals and subfecundity*. Hum Reprod, 2009. **24**(5): p. 1200-5.
21. Velez, M.P., T.E. Arbuckle, and W.D. Fraser, *Maternal exposure to perfluorinated chemicals and reduced fecundity: the MIREC study*. Hum Reprod, 2015. **30**(3): p. 701-9.
22. Jorgensen, K.T., et al., *Perfluoroalkyl substances and time to pregnancy in couples from Greenland, Poland and Ukraine*. Environ Health, 2014. **13**: p. 116.
23. Vestergaard, S., et al., *Association between perfluorinated compounds and time to pregnancy in a prospective cohort of Danish couples attempting to conceive*. Hum Reprod, 2012. **27**(3): p. 873-80.
24. Buck Louis, G.M., et al., *Persistent environmental pollutants and couple fecundity: the LIFE study*. Environ Health Perspect, 2013. **121**(2): p. 231-6.
25. Bach, C.C., et al., *Serum perfluoroalkyl acids and time to pregnancy in nulliparous women*. Environ Res, 2015. **142**: p. 535-41.