PFCs: Countless applications, new health risks

Background memo regarding the article on PFCs in JAMA, 25 January 2012, pages 391-397
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The group of substances known by the acronym PFCs (perfluorinated compounds) has thousands of applications, many of which lead to human exposures. However, as the substances were already in use when legislation on the testing of chemicals was adopted, they were exempt from the strict rules that apply to new chemicals.[1] Hence, industrial chemicals that have been in use for many years are not necessarily harmless.

PFCs are resistant to break-down, and their dissemination into the environment has caused contamination of food chains. Some of the highest concentrations have been found in polar bears far away from pollution sources. Several PFCs have been detected in human blood. Thus, concerns have been raised about the possible health risks associated with PFC exposure.[2]

Recent experiments have shown that PFCs can damage the immune system and, when injected into pregnant mice, PFC resulted in toxicity to the pups' immune system. The offspring were unable to produce the necessary antibodies toward a standard foreign protein. Surprisingly, the immunotoxicity occurred at blood PFC concentrations similar to those common in the US and other western populations.[3]

Study of vaccination responses

We therefore examined whether damage to the immune system may occur in children exposed to PFCs. As an expression of overall immune function, we measured the serum concentration of antibodies against tetanus and diphtheria; all children had been vaccinated against these diseases four times by age 5 years. The study was carried out in the Faroe Islands, where the marine diet results in exposures to environmental chemicals through contaminated marine food chains .[4] A total of 656 children – all born at the Faroese National Hospital – were enrolled in the study.

The PFC exposure was measured in blood samples taken at two points in time – from the pregnant mother at the last examination before birth, and from the child at age 5 years. Blood samples were obtained from a total of 587 of the children. Five different PFC compounds were measured and were found to be present in all blood samples. The child's antibodies were measured just before the last vaccination and again two years later at age 7 years. The results are available in the JAMA article just published.[5]

Doubling results in halving

The PFC content in the blood sample from the mother showed an inverse relationship with the child's level of antibodies at age 5, before the fourth vaccination. Thus the child's prenatal PFC exposure was associated with a decreased ability to produce antibodies later in life.

The most distinct effect was found in the 7-year-old children. The overall negative effect

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[1] Sass J. The chemical industry delay game. Natural Resources Defense Council, 2011. URL: http://www.nrdc.org/health/thedelaygame.asp

[2] PFCs: A case study in favour of the precautionary principle. URL: http://healthandenvironmentonline.com/2011/12/15/pfcs-a-case-study-in-favour-of-the-precautionary-principle/

[3] Dewitt JC et al. Immunotoxicity of perfluorinated compounds. Toxicol Pathol. 2011 Nov 22. [Epub ahead of print]

[4] www.chef-project.dk

[5] Grandjean P et al. Decreased serum vaccine antibody concentrations in children exposed to perfluorinated compounds. JAMA 2012; 307: 391-7.

corresponded to a halving of the antibody level when the PFC exposure doubled. This steep negative association suggests an influence that is stronger than the effect caused by dioxin exposure.[6] Only a few medical conditions, such as some rare hereditary diseases, radiation and certain types of cancer drugs, are otherwise known to interfere strongly with children's ability to respond to vaccinations.

For a child to obtain long-term protection against a disease, the content of antibodies in a blood sample must be of a certain minimum magnitude. PFC exposure increased the children's risk of not having a sufficient amount of antibody. Thus, the vaccinations did not have the desired effect.

Vaccinations to obtain immunity

Vaccination is considered one of the key elements of modern disease prevention. The purpose of childhood immunizations is to achieve sustained, preferably lifelong immunity, similar to the one achieved by going through a natural infection. The immune system encodes the formation of specific antibodies that help fend off the disease in case of subsequent infection.

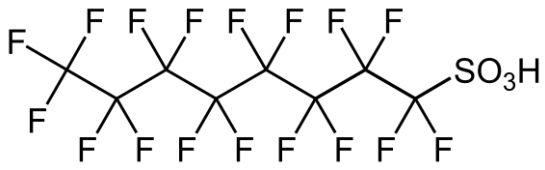
The new study calls into question whether routine childhood immunizations work as effectively as intended under these and perhaps also other circumstances. While it is well known that vaccinations do not always elicit the anticipated response, the reasons are uncertain. Environmental chemicals have only recently been considered as a possible culprit, and the new results suggest that this issue deserves greater attention.

The research group behind these findings has pioneered the study of children's formation of antibodies against vaccines and the possible negative impacts of pollution. Because the vaccinations are given to virtually all children – in the same dose and at the same age – the serum concentration of specific antibodies is an appropriate clinical marker of the immune system function.

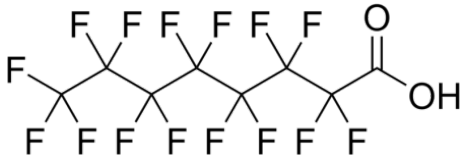
What are PFCs?

PFCs (perfluorinated compounds) are organic compounds containing an alkyl chain, where most or all hydrogen atoms have been replaced with fluorine. The fluorine substitution makes the molecule very stable and almost non-degradable in the environment. As seen below, the compounds may contain a functional group, usually an alcohol or an acid group. Several hundred different compounds are in current use, the most common ones being perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), which also occurred in the highest concentrations in our study.

PFOS



PFOA

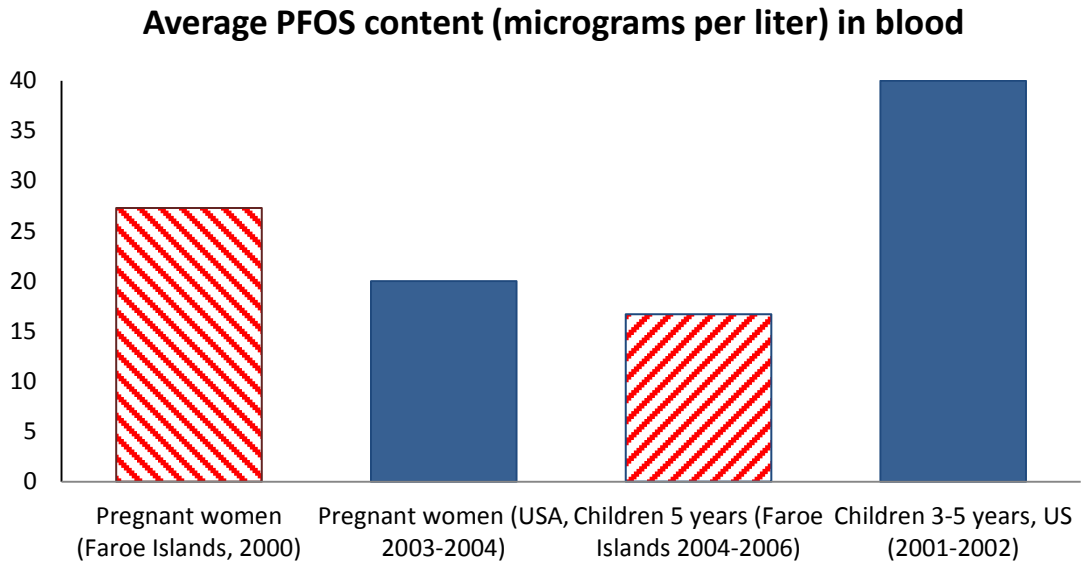


PFCs are highly useful for multiple purposes, because they are both water and grease resistant. This makes the PFCs suitable for coating of paper plates, food packaging, rainwear, shoes, upholstery, manufacture of non-stick pans, and many other purposes. The PFCs can be absorbed from contaminated food and drinking water, by inhalation of dust from treated products such as treated textiles, and from

[6] Heilmann C et al. Serum concentrations of antibodies against vaccine toxoids in children exposed perinatally to immunotoxicants. Environ Health Perspect 2010; 118: 1434-8.
http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.1001975

PFCs accumulated food chains due to environmental contamination. A recent report [7] showed that six out of ten paper bags and cardboard boxes used for food packaging contained PFCs. The compounds are most frequently used in bags for microwave popcorn. The extent to which the PFCs are transferred to the food is unclear, however.

Analysis of blood samples have shown that Americans, like Faroe Islanders and other Europeans are all exposed to PFCs. While some differences occur, Americans are exposed at roughly the same level as the Faroese who participated in the study, and children may have higher exposures than adults. The figure below shows the average PFOS content in the US and the Faroes.[8] During the last 10 years, concentrations have decreased as an apparent result of the discontinuation in 2002 of industrial PFC production in the US (production continues, e.g., in China).



Toxicity testing

Two PFC compounds – PFOS and PFOA – have been examined in a wide range of animal experiments, but only recently have researchers focused on the effects on the immune system. Such studies are not routine, and testing of immune toxicity is not required – not even in the EU's chemical legislation (REACH). When the European Food Safety Agency (EFSA) reviewed PFOS and PFOA, the proposed exposure limit was based on studies of harmful effects on the liver of rats. [9] These effects occur at an exposure 100 times higher than that recently found to cause immune damages in mice pups.

How to limit PFC exposure

Since the exact routes of PFC exposure are somewhat unclear, any advice and guidance on protection against PFCs are associated with some uncertainty. But it would be prudent to avoid microwave popcorn, treatment of furniture, carpets, shoes and clothing with stain repellants and likewise to avoid

[7] Trier X et al. Polyfluorinated surfactants (PFS) in paper and board coatings for food packaging. Environ Sci Pollut Res 2011; 18: 1108-20.

[8] US data are from Calafat AM et al. Polyfluoroalkyl chemicals in the U.S. population. Environ Health Perspect. 2007; 115:1596-602. Kato K et al. Polyfluoroalkyl compounds in pooled sera from children participating in the National Health and Nutrition Examination Survey 2001-2002. Environ Sci Technol 2009; 43: 2641-7.

[9] http://www.efsa.europa.eu/en/efsajournal/pub/653.htm

lubricants for skis and snowboards, unless it is known that the product not contain PFCs.[10] As PFCs are known to occur in indoor dust, frequent vacuuming may help limit children's exposure to these compounds.

PFOS was recently placed on the list of particularly hazardous substances (Stockholm Convention), but without the strict requirements that otherwise apply to other toxicants, such as dioxins. Several PFCs are on the list of substances that the International Chemical Secretariat has proposed for substitution.[11] The U.S. Environmental Protection Agency worked jointly with the chemical industry to phase out US production of PFOS in 2002. More recent actions have focused on decreasing production and emissions of other PFCs. Eight companies voluntarily agreed to reduce emissions and product content of PFOA and related chemicals by 95% by 2010, and to eliminate emissions by 2015. However, the fact that these chemicals are persistent in the environment and have a long half-life in humans means that exposures and serum concentrations will remain for many years, despite reductions in emissions. The U.S. EPA is currently evaluating the potential need for regulation of PFCs using the authorities of the Toxic Substances Control Act.[12]

The research group

The researchers behind the new study come from Harvard School of Public Health, Danish institutions (University of Southern Denmark, University of Copenhagen and Statens Serum Institut) and the Faroese health care system. Since 1985, members of this research group have collaborated on prospective studies of birth cohorts – children examined at birth and at intervals later on during development. The investigations have led to important discoveries that have been significant, e.g., in regard to international agreements on combating mercury pollution.

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For further information

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[10] http://www.ewg.org/files/EWG_pfcguide.pdf; http://www.environmentalhealthnews.org/ehs/news/ski-wax-chemicals

[11] http://www.chemsec.org/list/about-sin

[12] Long-Chain Perfluorinated Chemicals (PFCs) Action Plan Summary. URL: http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/pfcs.html