Children less attentive, more impulsive with higher exposure to repellent chemicals.

Jul 20, 2011

Gump, BB, Q Wu, AK Dumas and K Kannan. 2011. **Perfluorochemical (PFC) exposure in children: Associations with impaired response inhibition**. Environmental Science and Technology http://dx.doi.org/10.1021/es103712g.

Stein, CR, and DA Savits. 2011. **Serum perfluorinated compound concentration and attention deficit/hyperactivity disorder in children aged 5 to 18 years**. Environmental Health Perspectives http://dx.doi.org/10.1289/ehp.1003538.

Synopsis by Steven Neese and Joe Braun

PFCs are associated with attention and behavior problems in children, suggest a pair of studies published online in June. These studies are some of the first to explore the relationship between PFC compounds and behavior problems, specifically attention-deficit/hyperactivity disorder (ADHD) and impulsive behavior.

In one study, preteen children were more impulsive when they had higher blood levels of six PFC compounds. The other reports that children with higher blood levels of one type of PFC – PFHxS – have an increased chance of ADHD.

A variety of products use PFCs during manufacturing, and the compounds are present in just about everyone. Together, the reports suggest further research is needed to discern human health effects of PFC exposure.

Context

Perfluorinated chemicals (PFCs) have been used in the manufacture and processing of a variety of consumer and industrial products since the 1950s. The most notable uses are non-stick cookware, food packaging, waterproof fabrics, paints and stain-proof coatings (Begley et al. 2005; Olsen et al. 2005).

PFCs consist of a variety of different chemicals. The most studied include perfluorooctane sulfonate (PFOS), perfluorononanoic acid (PFNA), perfluoroctanic acid (PFOA) and perfluorohexane sulfate (PFHxS).

PFHxS was not intentionally made but appears to be an impurity from PFC production or a breakdown product. While it is generally found at lower concentrations, it takes longer to degrade than some of the other PFC varieties.

Exposure in people is widespread. The primary source of exposure is through food (Tittlemier et al. 2007), but contaminated dust is another big source (Bjorkland 2009). PFCs in household items – such as carpets – can escape and settle in house dust. Children frequently crawl, sit and play on floors, carpets and other areas where dust gathers. Because of this, children are generally more highly exposed to PFCs than adults.

Some of these chemicals are very stable. Their water-repellant properties make them persist in the environment, wildlife and the human body for years (Olsen et al. 2007). Population studies in the United States find PFCs in the blood of nearly everyone tested (NHANES). They are also detected in umbilical cord blood and breast milk.

Although exposures are widespread, little is known about human health impacts of PFCs, especially those related to behavior or nuerodevelopmental effects in children. Blood levels of some PFCs are associated with attention deficit hyperactivity disorder (ADHD) in children (Hoffman et al., 2010). ADHD is a neurological disorder characterized by impulsive/hyperactive behavior and difficulty concentrating.

A defining feature of ADHD is impulsive behavior. A number of other contaminants have been linked to deficits in behavior control in children. Environmental chemicals like polychlorinated biphenyls (PCBs), methylmercury and lead are related to impulsive behavior and ADHD. To date, few studies have examined whether PFC exposures impact child behavior.

What did they do?

Two separate studies published online last month examined ADHD and hyperactive and impulsive behavior in children and then compared the results to PFC levels in the children's blood.

In the first study, Brooks Gump and colleagues assessed impulsive behavior using a common behavioral test called the DRL task. They examined 83 children from Oswego County, N.Y., aged from 9 to 11 years old. They also measured six different PFC's – PFOS, PFOA, PFHxS, PFNA, perfluorodecanoic acid (PFDA) and perfluorooctanesulfonamide (PFOSA) – in the children's blood. Lead and mercury were also analyzed because they can alter DRL performance.

During the task, children press the space bar on a computer keyboard in order to earn a reward of 25 cents. The first three presses are rewarded, but thereafter, the task requires the child to wait 20 seconds between presses in order to earn the reward. Each correct space bar press results in the word "CORRECT" flashing on the computer screen.

In a second study published online in Environmental Health Perspectives, researchers Cheryl Stein and David Savitz reviewed data from the C8 Health Project survey conducted between 2005 and 2006. The project examined more than 10,000 parents and their 5- to 18-year-old children who lived in West Virginia and Ohio near a DuPont plant that manufactures PFOA. The communities surrounding this plant are highly exposed to PFOA from their tap water and plant emissions.

The researchers measured the concentrations of PFOA, PFOS, PFHxS and PFNA in the children's blood. They asked the parents a series of questions, including whether their child had a learning disability or was diagnosed with ADHD or used ADHD medications like Ritalin.

In both studies, gender, income, education and other lifestyle factors were considered in the analysis.

What did they find?

The complementary studies found associations between PFCs and behavioral disorders.

PFCs were detected in the blood of children from both studies. Overall, most tweens in the Gump et al. study had significant levels of multiple chemicals in their blood. All children had blood levels of PFOS, PFOA and PFHxS, and these three chemicals made up the majority of the total chemicals measured in the children.

These same three PFCs plus PFNA were found in the children participating in the C8 study. In this group, PFOA levels were the highest of the four measured compounds. Surprisingly, PFOA concentrations were not associated with ADHD in this group of children.

However, higher concentrations of PFHxS were associated with increased odds of ADHD. Odds is a measure of probability of an event occurring. When the probability of the event is low, then the odds will approximate the probability. Children with the highest exposure to PFHxS were 60 percent more likely to have ADHD and take ADHD medication. The other two PFCs were not strongly associated with ADHD. None of the PFCs were associated with report of a learning problem.

Gump et al. takes a slightly different research approach yet reports a similar finding. In their study, total and individual PFC levels were associated with impulsive behavior. Increasing blood levels of total PFCs were associated with earlier and more frequent responses on the DRL task, clearly seen during the last 15 minutes of a 20-minute testing session. Increases in premature responses also related to blood levels of five individual chemicals, including PFOS, PFNA, PFDA, PFHxS and PFOSA. However, the blood levels of the chemicals measured are highly correlated, making it difficult for researchers to tell which PFCs may have the most influence.

What does it mean?

Taken together, these studies suggest that exposure to PFCs can influence behavior in children. Since little is known about the health effects of PFC exposure, the studies highlight the need for additional research to better understand the human health effects of exposures to these chemicals.

The research teams report in the different studies that PFCs alone or in a mixture can increase impulsive behavior in children while higher levels of a lesser-known PFC – PFHxS – influenced ADHD in children and teens.

The studies are important in different ways, but both are consistent with prior findings.

The results of Gump et al. are the first to directly relate blood PFC levels to impulsive behavior. While the results of this study are unique for PFCs, they are similar to children's DRL performances after prenatal exposure to other contaminants, including PCBs and mercury (Stewart et al. 2006). One limitation of the current study is that other toxicants – including PCBs – that impact DRL performance were not measured.

Stein and Savitz's findings from the C8 Study are unique because they examined a very large number of children, and the children were highly exposed to PFOA. These results are highly consistent with the only other study to look at the relationship between measured blood levels of PFHxS and ADHD. The prior study examined teens aged 12- to 18-years-old and also found an association (Hoffman et al. 2010).

Human exposures of PFOS have declined in recent years, but contact with other chemicals such as PFNA has not (Kato et al., 2011). The measured impulsiveness and a possible link to ADHD raise concerns about continued human exposures to PFCs, especially in children. Future studies will need to confirm these findings and determine if early life and childhood exposures impact other health outcomes.

Resources

C8 Science panel and research program. http://www.c8sciencepanel.org/index.html

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