

The Science of PCBs and Health: A Selective Summary

Compiled by New York Lawyers for the Public Interest

Note: the articles in parenthesis are identified in full in the bibliography at the end.

CANCER

- Children's risk of developing the most common form of childhood leukemia, acute lymphocytic leukemia, increased twofold when PCBs were detected in the dust of a room in which the child spent a significant amount of time (Ward, 2009).
- PCBs act as general cancer promoters. Because of the way they behave in the body they are expected to increase risk of every kind of cancer (Carpenter, 2006; Tharappel, 2002).
- Exposure to high levels of PCBs has been consistently and strongly linked to increased risk of non-Hodgkin lymphoma (NHL) (Freeman and Kohles, 2012; Kramer et al., 2012).
- In a study of workers in an Indiana capacitor-manufacturing plant, the highest rates of brain cancer occurred among workers with the highest rate of PCB exposure (Ruder, 2005; Carpenter, 2006).
- Some studies have shown an elevated risk of developing gastrointestinal cancers. One study recorded elevated incidence of intestinal cancer in women, and stomach cancer in men, who worked for 5 or more years in a plant that used PCBs (Mallin, 2000; Carpenter, 2006).
- Liver cancers are among the most common tumors to form during animal studies regarding PCB exposure. Occupational studies have also indicated an increased risk of developing liver tumors after being exposed to PCBs (Brown, 1987; Gustavsson 1997; Carpenter, 2006).
- Studies have demonstrated an increased risk of prostate cancer among farmworkers who used three different types of PCBs (Richie, 2003; Richie, 2005; Carpenter, 2006).
- Thyroid cancer is another commonly reported cancer seen during animal PCB exposure studies (Mayes, 1998; Vansel, 2004; Carpenter 2006).
- Women who were exposed to higher levels of a certain type of PCB during their reproductive years are three times more likely to develop breast cancer later in life (Cohn et al., 2012).

AUTISM/AUTISM SPECTRUM DISORDER (ASD)

- Pre- and early post-natal exposure to PCBs is associated with deficit or retardation of mental and/or motor development, even after adjusting for maternal intelligence and developmental effects of the quality of the home environment (Winneke, 2011).

- PCBs have been identified as an environmental risk factor for neurodevelopmental disorders, especially in children with heritable deficits in calcium-signaling associated with autism (Wayman, Bose, et al., 2012).
- Perinatal exposure to endocrine-disrupting chemicals such as PCBs appears to be associated with the occurrence of Autism Spectrum Disorder and Attention Deficit-Hyperactivity Disorder (de Cock, 2012).
- PCB exposure to the developing brain can promote dendritic growth and influence neuronal connectivity (Wayman et al., 2012). This is significant because structural aberrations in the dendritic arbors of central neurons are thought to contribute to autism spectrum disorder and other neurodevelopmental disorders (Bourgeron, 2009; Fukuda et al., 2005; Garey, 2010; Penzes et al., 2011; Svitkina et al., 2010).

BEHAVIORAL, LEARNING, & COGNITIVE FUNCTION

- Adults who work in buildings in which window caulk is contaminated with PCBs showed higher rates of attentional deficits (Peper, 2005).
- Low-level prenatal exposure to PCBs is associated with an increase in ADHD-like behaviors in children (Sagiv, 2010).
- Children who had prenatal exposure to PCBs had higher incidence of behavioral disorders and lower IQ scores when they were 9 years old (Stewart, 2008).
- Adolescents with elevated serum PCBs do more poorly on several tests of cognitive function than do adolescents with low PCBs (Newman et al., 2009).
- PCB exposure and ingestion has been associated with slower reaction times. Postnatal PCB exposure can affect cognitive processes associated with error monitoring, behavioral regulation, and the ability to adapt to a changing environment, all of which results in reduced task efficiency (Boucher et al., 2012) .
- One study found an association between PCB exposure and neuropsychological attention deficits in boys (Sagiv et al., 2012).
- Developmental exposure to some types of PCBs decreases the learning ability of young rats. PCBs are thus a risk factor in developmental neurotoxicity in laboratory rodents and humans (Campagna et al., 2011).

EFFECTS ON THE CENTRAL NERVOUS SYSTEM

- Exposure to PCBs has been found to produce profound damage to both the developing and adult central nervous systems (Selvakumar et al., 2012).
- Exposure to PCBs has been shown to adversely affect psychomotor function, learning, memory, and the growth and function of the central nervous system in humans. PCBs may also alter energy metabolism and intracellular signaling, which might result in developmental neurotoxicity (Kodavanti et al., 2011).
- The negative effects of exposure to PCBs on early psychomotor development suggest that the potential neurotoxic effects of these compounds may be evident even at low doses (Forns et al., 2012).

- Because PCBs produce anti-estrogenic activity, they may interfere with normal estrogen-activated processes, leaving neurons more vulnerable to dangerous stimuli. This phenomenon may be relevant in the development of neurodegenerative diseases such as Alzheimer's (Bang et al., 2011).

DIABETES

- Having elevated PCB levels early in life is predictive of developing diabetes later (Lee et al., 2010).
- In Anniston, Alabama, where PCBs were manufactured from 1929 to 1971 and the population is one of the most exposed in the world, there are significant associations between elevated PCB levels and diabetes (Silverstone et al., 2012).
- After accounting for other risk factors, a recent study found that people who had high levels of PCBs were up to nine times more likely to be diagnosed with Type 2 diabetes than those with very low levels of pollutants in their blood (Lee, 2011; Codru et al., 2007; Airksinen et al., 2011).
- Hospitalization rates for diabetes in communities near a toxic waste site containing PCBs were amplified (Kouznetsova, 2007).

EFFECTS ON THE ENDOCRINE SYSTEM

- Adolescent girls with high PCB levels reach puberty at a younger age than girls with lower PCBs (Denham et al., 2005). Similarly, boys who were subjected to prenatal and early-life PCB exposures were more likely to experience accelerated pubertal onset (Humblet et al., 2011).
- Thyroid function is reduced if serum PCB level is elevated (Schell et al., 2008). Since thyroid hormones are essential for normal brain development during fetal and neonatal periods, PCB-induced decreased thyroid function has been linked to impaired neurodevelopment of children (Arisawa et al., 2005; Koopman-Essenoom et al., 1994; Nagayama et al., 1996).
- Higher PCB levels in men are associated with a reduction in the levels of the male sex hormone, testosterone (Goncharov et al., 2009).
- PCBs have been found to act as agonists or antagonists against steroid hormone receptors such as glucocorticoid receptor (GR), Estrogen Receptor β (ER β), and androgen receptor (AR). GR is responsible for regulating genes controlling development, metabolism, and immune response; ER β serves a variety of purposes, including contributing to DNA transcription, supporting the adaptive function of the lungs during pregnancy, and acting as a tumor suppressor; and AR regulates genes that are critical for the development and maintenance of the male sexual phenotype (Takeuchi et al., 2011).

HEART DISEASE & HYPERTENSION

- Other than age, total serum PCB concentration is the strongest determinant of whether or not a person will develop hypertension (Goncharov et al., 2010; Yorita Christensen, 2011).
- Residents living in communities adjacent to the Hudson River, which contains high levels of PCBs, had an increased rate of hospitalization for coronary heart disease by over 35% and for acute myocardial infarction by nearly 40% (Sergeev, 2005).

- High levels of PCBs cause the liver to make more cholesterol and lipids, which then increase the risk of cardiovascular disease (Goncharov et al., 2008).
- Elevated blood serum concentrations of PCBs were positively associated with self-reported history of cardiovascular disease among females (Ha, Myung-Hwa et al. 2007).

EFFECTS ON THE IMMUNE SYSTEM

- PCBs are associated with immune system disruptions including increases in B cells and decreases in CD8+ and natural killer cells (Svesson, 1994; Miller VM, Sanchez-Morrissey S, et al., 2012; Park, 2008).
- Babies with higher prenatal PCB exposures had reduced immune response after vaccination for measles, mumps, and rubella (Weisglas-Kuperus, 2000). Children with higher rates of PCB exposure exhibited decreased antibody response after vaccination against tetanus and diphtheria (Heilmann, 2006; Barrett, 2010).
- Infants fed milk contaminated with PCBs had a 20-fold higher incidence of infectious diseases, including measles, meningitis, and middle ear infections, than did children with less exposure (Dewailly, 2000).
- Prenatal and early life exposure to PCBs is associated with increased incidence of infectious and allergic diseases in children (Horváthová et al., 2011).

PRENATAL & INFANT EXPOSURE

- Even low-level prenatal exposure to PCBs may affect thyroid hormone homeostasis (Chevrier, 2007).
- Prenatal exposure to PCBs may affect growth, especially in girls (Lamb, 2006; Hertz-Picciotto, 2003; Elabbas et al., 2011).
- Associations were reported between prenatal PCB and p,p-DDE exposures and poor attention in early infancy, including alertness, quality of alert responsiveness, and cost of attention (Sagiv, 2008).
- PCB exposure causes a variety of adverse health effects, including neurotoxicities such as cognitive deficits and motor dysfunction. Infants less than four months of age are at a particularly high risk for these adverse effects (Do, Lee, 2012).
- There is a correlation between pre/perinatal PCB exposure and reduced neonatal height, weight, Apgar scores, gestational age, and body mass index (Wu et al., 2011; Kokichi et al., 2005).
- Exposure to PCBs at the time of gonadal sex determination significantly perturbed the reproductive physiology of male and female offspring in adulthood. In males, these reproductive deficiencies may be observed in at least two further generations (Pocar, 2012; Su et al., 2012; Casati et al., 2012).
- An impairment of neuropsychological development was reported among Taiwanese children born to mothers who had been accidentally exposed to high levels of PCBs (Guo et al., 2004).

- High levels of PCB exposure were associated with hypertonicity (excessive tension of the arteries or muscles) and hyporeflexia (a condition of having below normal or absent reflexes), as assessed by the Neonatal Behavioral Assessment Scale (Rogan et al., 1986).

RESPIRATORY EFFECTS/ASTHMA

- Adults and children have an increased risk of asthma and infectious respiratory diseases when exposed to PCBs (Carpenter, 2008; Ma, 2007).
- One study illustrated that children with higher PCB levels in their blood were more prone to coughing, chest congestion, and phlegm (Weisglas-Kuperus, 2000; Carpenter, 2006; Nakanishi, 1985).
- Despite living healthier lifestyles than other New Yorkers, individuals living along the Hudson River, which is severely contaminated with PCBs, displayed higher rates of hospitalizations for chronic respiratory infections (Kudyakov, 2004)

REPRODUCTIVE EFFECTS

- Dioxin-like PCBs may be involved in the development of endometriosis (Rier et al., 2001).
- As PCB serum levels increase, the probability of conception decreases (Gesink Law et al., 2005). Other studies have suggested an increased risk of miscarriage with increasing PCB exposure (Leoni et al., 1989; Gerhard et al., 1998; Pocar et al., 2003).
- Increased concentration of PCB exposure is associated with increased menstrual cycle length and irregularity (Cooper et al., 2005).
- Associations were reported between blood serum PCB concentrations at levels similar to the US general population and increased odds of failed implantation among women undergoing *in vitro* fertilization (Meeker, 2011).

MISCELLANEOUS

- Low-level environmental PCB pollution was associated with the development of liver disease and suspected nonalcoholic fatty liver disease (Cave, 2010).
- Recent epidemiological studies have demonstrated a link between PCBs exposure and pathological alternations of bone tissues (An et al., 2012).
- PCBs exposure significantly diminishes the activity of telomerase, an enzyme that prevents the loss of important DNA information from chromosome ends. Any cell type with significant telomerase activity, such as stem cells, for example, may be adversely affected by PCBs exposure, thus risking a variety of adverse health effects for the affected organism (Senthilkumar et al., 2012).
- Developmental exposure to PCBs causes hearing loss that may be attributable to reduced thyroxine during cochlear development. Co-exposure to PCBs and polybrominated diphenyl ethers (PBDEs) can amplify this effect (Poon et al., 2012).

METHODS & PERSISTENCE OF EXPOSURE

- Elevated levels of PCBs can persist in the human body over many years (Seegal, 2010).
- Teachers in PCB-containing schools had elevated levels of PCB congeners in their blood. In particular, they exhibited higher concentrations of lighter PCB congeners, which are more likely to come from non-dietary sources, such as building materials. These lighter congeners include several that are believed to be endocrine-disrupting developmental toxins (Herrick, 2011).
- Inhalation is a major exposure pathway for PCBs and may lead to a greater uptake of PCBs than ingestion (Currado, 2008).
- Workers distributing PCB caulk had elevated PCB concentrations in their blood (Kontsas, 2003; Wingfors, 2006; Herrick, 2007).

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