MIND, DISRUPTED

How toxic chemicals may change how we think and who we are

Mercury

What Is Mercury?

Mercury is a heavy metal that is naturally found in several forms in the environment—elemental, inorganic, and organic forms. Elemental mercury (quicksilver) is liquid at room temperature; inorganic mercury occurs when mercury combines with other elements to form salts; and organic mercury is formed when mercury combines with carbon. When elemental mercury is released into soil and water, microscopic organisms can convert it to methylmercury, which can bioaccumulate in the food web—especially aquatic food webs—building up in fish, marine mammals, and humans.[1,2,3]

Major sources of mercury emissions (approximately 70%) come from anthropogenic releases through coal-fired power plants, chloralkali production (where chlorine and caustic soda are produced through electrolysis of brine), municipal and medical waste incinerators, mining operations and other industrial sources.[4,5,6] Elemental mercury is also utilized for electrical equipment (thermostats and switches) and medical equipment such as sphygmomanometers (blood pressure cuffs), thermometers, and silver-colored dental amalgams used for fillings.[3] Fluorescent light bulbs, some batteries, and pigments may also contain mercury.[3] These items may contaminate the environment if thrown away improperly in a landfill or incinerator. Certain organic mercury compounds are used for pharmaceutical applications as preservatives (thimerosal and phenylmercuric acetate) and topical antiseptics (merbromin).[3] Mercury is also found in some cosmetic skin creams from countries other than the United States and in certain folk medicines.[3] Volcanoes and other natural sources also release small quantities of elemental mercury into the environment.[6]

How Are We Exposed?

Elemental Mercury

Exposure to elemental mercury can occur through inhalation of contaminated air near mines; hazardous waste sites; landfills; dump sites containing light bulbs, batteries, and medical waste; workplaces such as dental offices or industries that use mercury; or in locations where a mercury release has taken place.[1,3]

Occupational exposures can occur in mine workers who may be exposed to mercury through inhalation of mercury vapor.[7] Elemental mercury is only minimally absorbed after eating contaminated items or through the skin.[1] Except for occupational exposure, mercury in dental amalgams is the typically the most common source of inorganic mercury.[8]

Methylmercury

Inorganic mercury is converted to methyl mercury in waterbodies. As a result, the primary source of exposure to methylmercury is through consumption of contaminated fish and seafood.[9,10,11,12] Methylmercury is present at some level in all fresh and saltwater fish, but some fish have higher levels than others.[9] Because methylmercury builds up in muscle tissue, eating large, predatory fish and other marine wildlife at the top of the aquatic food web commonly causes higher exposures.[1,5,9,13]

Methylmercury exposure occurs in fetuses and infants because it readily crosses the placenta and can be present in breastmilk.[1,11,14]

Mercury exposure can also occur through consumption of food items that are not fish. It has been detected in commercial high fructose corn syrup which is presently ubiquitous in processed foods, including baby formula.[15,16]

Mercury In Our Bodies

From 1999-2006, scientists from the U.S. Centers for Disease Control and Prevention (CDC) measured blood levels in 16,780 people as part of a nationwide assessment—known as the National Health and Nutrition Examination Survey (NHANES)—of the exposure of the U.S. population to mercury. Over this period of time, blood mercury levels increased slightly for non-Hispanic white children and decreased slightly for non-Hispanic black and Mexican American children. Overall, female children had slightly higher blood mercury levels than male children. During 2003-2006, total blood mercury levels were found to increase with age, reaching the highest levels in the fifth or sixth decade and then declining. Levels were found to be generally higher for non-Hispanic blacks and non-Hispanic whites than for Mexican Americans. In the most recent survey years of 2005–2006, the 95th percentile (meaning that an estimated 95 percent of

the U.S. population's exposure level is below this level) for children aged 1–5 years was 1.43 µg/L and for females aged 16–49 was 4.48 µg/L.[2]

Data collected from the NHANES in 1999 and 2000 revealed that blood mercury levels were seven times higher in women who reported eating fish and/or shellfish within the past 30 days (prior to testing) compared with women who reported they had not. Based on the concentrations of adult female participants in the 1999–2000 NHANES, it is estimated that more than 300,000 newborns born in the U.S. each year may have been exposed *in utero* to methylmercury levels higher than those considered to be without increased risk of adverse neurodevelopmental effects.[17]

What Does Exposure to Mercury Mean for Our Health?

The presence of environmental chemicals in the human body does not necessarily imply that they are causing adverse health effects; however, environmental chemical exposures can and do affect human health. It is important to note that both the dosage and the timing of exposure have significant effects on any potential health outcome.

The following information is intended to inform the reader about the current state of knowledge on the health effects of mercury, including both human and animals studies.

Neurological Toxicity

Mercury is a potent neurotoxin that is known to cause learning and developmental disorders.[18] At high exposure levels associated with catastrophic environmental releases of mercury, it can cause mental retardation, cerebral palsy, and seizures.[9,10,19] Methylmercury has long been known to adversely influence neurodevelopment in both humans and experimental animals. Neurobehavioral effects reported include altered motor function and memory, as well as learning disabilities.[20] Methylmercury is highly toxic and is linked to a variety of adverse health effects on the central nervous system, including visual and hearing impairment, tremors, and muscle spasms.[1] There is strong evidence that mercury exposure is linked to diseases such as cerebral palsy; impaired learning, memory, coordination, and attention span; mental retardation; hearing loss; dermatitis; psychiatric disturbances; seizures;[19] and acute bronchitis and pneumonitis.[21] In a study of men from the Faroe Islands who consumed large amounts of seafood, symptoms arose when blood mercury levels reached approximately 58 µg/L.[22]

Developing fetuses and children are particularly vulnerable to mercury intoxication, which may lead to impairment of the developing central nervous system, as well as pulmonary and nephrotic damage.[10,23,24] One study found that prenatal methylmercury exposure through mothers' regular consumption of fish and marine mammals resulted in deficits in language, attention, and memory in children,[25] even after researchers controlled for co-contamination by PCBs.[26]

Early signs of long-term exposure to elemental mercury may include the following nonspecific symptoms of the central nervous system: insomnia, forgetfulness, loss of appetite, and mild tremor. These symptoms may be misdiagnosed as psychiatric illness.[1]

Reducing Your Exposure

You can prevent or minimize exposure to mercury in the following ways:

- Try to avoid eating long-lived and large predator fish that are known to be higher in mercury, such as king mackerel, tilefish, swordfish, orange roughy, and marlin. Try to limit your consumption of tuna, especially steaks and canned 'white' albacore. Fish that have been found to have lower-mercury levels are wild salmon, sardines, anchovies, Atlantic herring, Dungeness crab, Pacific cod, Alaskan black cod, farmed striped bass, tilapia, farmed catfish, clams, mussels, and Pacific oysters. Contact your state or local public health or natural resource department to learn about possible wildlife and fish advisories in your area. Many guides are available to assist in evaluating the mercury levels in fish:
- Monterey Bay Aquarium: *www.montereybayaquarium.org/cr/cr_seafoodwatch/download.aspx*
- Environmental Defense's Oceans Alive: *www.edf.org/page.cfm?tagID=1521*
- Environmental Working Group's Tuna Calculator: *www.ewg.org/tunacalculator*
- Responsibly dispose of products that may contain mercury, such as thermometers, thermostats, fluorescent light bulbs, and batteries. Do not burn these items. For instructions on and locations for recycling these products, contact your municipality or waste management company.
- For instructions on safe clean-up of broken fluorescent light bulbs, please see the ENERGY STAR fact sheet at: *www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf* or call the ENERGY STAR Hotline at 888-STAR-YES (888-782-7937).
- In the event of household spills, pregnant women, children and teens should keep away from the room. Do not vacuum spilled mercury. This can cause the mercury to vaporize and increase the potential for exposure. Teach children and teens not to play with liquid mercury. If a large amount of mercury has been spilled, immediately contact your health department and local Hazardous Waste Disposal agency.

Cardiovascular Effects

A recent study found that higher levels of mercury (as assessed in blood, hair, and toenails) was significantly associated with increased blood pressure and common carotid intima-media thickness (an indicator of atherosclerosis). The study was carried out in highly exposed population, but the results support the notion that increased methylmercury exposure promotes the development of cardiovascular disease.[22] Consumption of fish containing methyl-mercury has been shown to increase the risk of heart attacks. Omega-3 fatty acids in the fish reduced that risk, but consumption of large amounts of contaminated fish had an overall negative effect.[27]

Immune System Effects

Mercury is also known to have adverse effects on the immune system. Mercury is associated with suppression of immune resistance to pathogens in mice.[28] There is evidence that mercury promotes the development of autoimmune disease in animals. However, these effects develop at significantly higher doses than those experienced by most people.[29] There is also evidence that mercury may increase the risk and severity of unrelated diseases in highly exposed populations.[30]

Cancer

Mercury is a known mutagen (an agent that changes, or mutates, genetic material) and teratogen (an agent that disrupts fetal or embryonic development) and a suspected carcinogen.[5] While the EPA has not classified elemental mercury as a human carcinogen, based on "inadequate human and animal data,"[31] it has determined that methylmercury is a possible human carcinogen.[14,32]

Regulation of Mercury

In the United States, mercury is regulated under multiple federal and state statutes and multiple agencies. The Environmental Protection Agency (EPA) regulates mercury in pesticides and releases into the environment through air, water, land, and as hazardous waste.[33] The EPA has set a limit of 2 parts of mercury per one billion parts of drinking water (2 ppb).[14]

The Food and Drug Administration (FDA) regulates mercury in cosmetics, food, and dental products.[34] The FDA has set a maximum permissible level of 1 part of methylmercury per one million parts of seafood (1 ppm).[14]

The Occupational Safety and Health Administration (OSHA) regulates mercury air exposures in the workplace.[34] OSHA has set limits of 0.1 milligram of organic mercury per cubic meter of workplace air (0.1 mg/m^3) and 0.05 mg/m^3 of metallic mercury vapor for 8-hour shifts and 40-hour work weeks.[14]

Many states have implemented restrictions on mercury-containing consumer products, such as banning the sale of certain products containing mercury, limiting the content of mercury in some products, and imposing recycling requirements and disposal restrictions on mercury-containing products.[34,34]

Effective June 1, 2009 the Swedish government implemented a blanket ban on mercury meaning that products containing mercury will no longer be allowed on the Swedish market and dental amalgams will no longer be used. Instead, alternative techniques and less harmful substitutions wil be utilized.[35]

Endnotes

1 Etzel RA, Balk SJ, eds. 2003. *Pediatric Environmental Health*. 2nd ed. Elk Grove Village, IL: American Academy of Pediatrics.

2 United States Centers for Disease Control and Prevention (CDC). May 2009. *Mercury*. Available at: *www.cdc.gov/ExposureReport/pdf/factsheet_mercury.pdf.*

3 United States Centers for Disease Control and Prevention (CDC). 2005. *Third National Report on Human Exposure to Environmental Chemicals*. Atlanta, GA: CDC.

4 Schettler T, Stein J, Reich F, Valenti M. 2000. *In Harm's Way: Toxic Threats to Child Development.* Cambridge, MA: Greater Boston Physicians for Social Responsibility.

5 Eisler R. 2004. Mercury hazards from gold mining to humans, plants, and animals. *Rev Environ Contam Toxicol 181*: 139-198.

6 United Nations Environmental Programme (UNEP). 2002. Global Mercury Assessment Report. New York: United Nations Environmental Programme. Available: *www.chem.unep.ch/mercury/Report/GMA-report-TOC.htm*

7 Breithaupt A. 2009. *A Case for the Development of Mercury Regulations for Alaska's Existing and Proposed Gold Mines.* Anchorage: Alaskans for Responsible Mining. Available: *www.earthworksaction.org/publications.cfm?pubID=399*

8 Bates, MN. 2006. Mercury amalgam dental fillings: an epidemiologic assessment. *Int. J. Hyg. Environ.-Health* 209:309-316

9 Myers, GJ and Davidson PW. June 2000. Does Methylmercury Have a Role in Causing Developmental Disabilities in Children? *Environmental Health Perspectives* 108(S3): 413-420.

10 Gilbert SG and Grant-Webster S. 1995. Neurobehavioral Effects of Developmental Methylmercury Exposure. *Environmental Health Perspectives* 103(S6): 135-142.

11 Myers GJ and Davidson PW. 1998. Prenatal Methylmercury Exposure and Children: Neurologic, Developmental, and Behavioral Research. *Environmental Health Perspectives* 106(S3): 841-847.

12 Trasande L, Landrigan PJ, and Schechter C. 2005. Public Health and Economic Consequences of Methyl Mercury Toxicity to the Developing Brain. *Environmental Health Perspectives* 113(5): 590-596.

13 United States Geological Survey. 2000, October. Mercury in the Environment. Fact Sheet 146-00. Available: *www.usgs.gov/themes/factsheet/146-00/*

14 Agency for Toxic Substances and Disease Registry. 1999. ToxFAQs for Mercury. Available at: *www.atsdr.cdc.gov/tfacts46.html#bookmark05*.

15 Dufault M, LeBlanc B, Schnoll R, Cornett C, Scheitzer L, Wallinga D, Hightower J, Lyn P, Lukiw WJ. 2009. Mercury from chlor-alkali plants: measured concentrations in food product sugar. *Environmental Health* 8:2. doi:10.1186/1476-069X-8-2

16 Wallinga D, Sorensen J, Mottl P, Yablon B. 2009. Not So Sweet: Missing Mercury and High Fructose Corn Syrup. Institute for Agriculture and Trade Policy. Available at: *www.healthobservatory.org/library.cfm?refid=105026*.

17 Mahaffey KR, Clickner R, and Bodurow C. 2004. Blood Organic Mercury and Dietary Mercury Intake: National Health and Nutrition Examination Survey, 1999 and 2000. *Environmental Health Perspectives* 112(5):562-570.

18 Gilbert, SG. 2008. Scientific Consensus Statement on Environmental Agents Associated with Neurodevelopmental Disorders. Developed by the Collaborative on Health and the Environment's Learning and Developmental Disabilities Initiative.

19 Collaborative on Health and the Environment. n.d. CHE toxicant and disease database. Available: *http://database.healthandenvironment.org/index.cfm*

20 Johansson C, Castoldi AF, Onishchenko N, Manzo L, Vahter M, Ceccatelli S. 2007 Neurobehavioural and molecular changes induced by methylmercury exposure during development. *Neurotoxicity Research* 11(3,4):241-260.

21 Jaffe KM, Shurtleff DB, Robertson WO. 1983. Survival after acute mercury vapor poisoning. *Am J Dis Child 137*:749-751.

22 Choi AL, Weihe P, Budtz-Jergensen E, Jorgenson PJ, Salonen JT, Tuomainen TP, Murata K, Nielson HP, Pertersen MS, Askham J, Grandjean P. 2009. Methylmercury Exposure and Adverse Cardiovascular Effects in Faroese Whaling Men. *Environmental Health Perspectives* 117(3): 367-372.

23 Counter SA, Buchanan LH. 2004. Mercury exposure in children: a review. *Toxicology and Applied Pharmacology* 15;198(2):209-30.

24 Rice DC. 1995. Neurotoxicity of Lead, Methylmercury, and PCBs in Relation to the Great Lakes. *Environmental Health Perspectives* 103(S9):71-87.

25 Grandjean P, Weihe P, White RF, Debes F, Araki S, Yokoyama K, Murata K, Sorensen N, Dahl R, Jorgensen PJ. 1997. Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. *Neurotoxicol Teratol* 6:417-428

26 Budtz-Jorgensen E, Keiding N, Grandjean P, White R, Weihe P. 1999. Methylmercury toxicity independent of PCB exposure. *Environmental Health Perspectives 107*(5): A236-7.

27 Guallar E, Sanz-Gallardo MI, Van't Veer P, Bode P, Aro A, Gomez-Aracena J, Kark Jd, Riemersma RA, Martin-Moreno JM, Kok FJ. 2002. Mercury, fish oils, and the risk of myocardial infarction. *N Engl J Med* 347(22):1747- 1754

28 Christensen MM, Ellermann-Eriksen S, Rungby J, Mogensen SC. 1996. Influence of mercuric chloride on resistance to generalized infection with herpes simplex virus type 2 in mice. *Toxicology* 15:57–66.

29 Havarinasab S, Hultman P. 2005. Organic mercury compounds and autoimmunity. *Autoimmunity Reviews.* 4:270-275

30 Silbergeld EK, Silva I A, Nyland JF. 2005. Mercury and autoimmunity: implications for occupational and environmental health. *Toxicology and Applied Pharmacology* 207:s282-292

31 US EPA Integrated Risk Information System (IRIS). 2008, January 10. Mercury, elemental (CASRN 7439-97-6). Available: *www.epa.gov/iris/subst/0370.htm*

32 US EPA. Integrated Risk Information System (IRIS). 2008, January 10. Methylmercury (MeHg) (CASRN 22967-92-6). Available: *www.epa.gov/iris/subst/0073.htm*

33 US EPA. 1998. Updated 2008. Great Lakes Binational Toxics Strategy, Stakeholder Forum – 1998; Implementing the Binational Toxics Strategy; Mercury Workgroup; Background Information on Mercury Sources and Regulations. Available at: *www.epa.gov/glnpo/bnsdocs/mercsrce/mercreg.html*

34 Lowell Center for Sustainable Production, University of Massachusetts Lowell. Chemicals Policy Initiative: US State Level Chemicals Policy Database. Available at: *http://chemicalspolicy.org/uslegislationsearch.php*

35 Swedish Ministry of the Environment. 2009. Press Release: Government bans all use of mercury in Sweden. Available at: *www.regeringen.se/sb/d/11459/a/118550*.

ACAT Alaska Community Action on Toxics

COMMONWEAL

Fact sheets on toxic chemicals for the *Mind, Disrupted* Biomonitoring Project provided by the Alaska Community Action on Toxics (www.akaction.net) and Commonweal (www.commonweal.org). For more information, please visit the *Mind, Disrupted* website at www.minddisrupted.org, or contact Pam Miller at pkmiller@akaction.net or Sharyle Patton at spatton@igc.org.