Methylmercury Effects and Exposures: Who Is at Risk?

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Two articles in this issue of EHP represent recent syntheses of research on the effects of mercury exposure from fish consumption: Karagas et al. (2012) reviewed the emerging research on health effects of low-level exposures to methylmercury (MeHg), and Oken et al. (2012) summarized the complexities of providing clear and uniform fish consumption advice to reduce MeHg exposure while balancing nutrient intake, ecologic concerns, and economic issues. These two papers emerged from workshops convened in September 2010 and July 2011 by the Coastal Marine Mercury Ecosystem Research Collaborative (C-MERC) and sponsored by the Dartmouth Superfund Research Program and its partners. C-MERC brought together a group of 50 scientists and stakeholders to work jointly to gather and analyze existing data and to publish synthesis papers on the fate of mercury from its environmental sources to seafood consumers—issues of critical importance for informing public policy.

Mercury, particularly its organic form (MeHg), is a global contaminant and toxicant of major concern for humans and wildlife (Driscoll et al. 2007; Fitzgerald et al. 2007; Grandjean et al. 2005; Mahaffey et al. 2009). Mercury is third (after arsenic and lead) on the 2011 Agency for Toxic Substances and Disease Registry (ATSDR) priority list of 275 hazardous substances (ATSDR 2011), which includes substances that present the most significant potential threats to human health in the United States. MeHg has long been known as a potent neurotoxicant, particularly due to incidents of acute and high-level exposures (e.g., Minamata, Japan; Iraq), but neurological effects have been documented in island populations that consume large quantities of seafood (Axelrad et al. 2007; Cohen et al. 2005; Rice 2004). Moreover, recent epidemiologic studies have revealed evidence of a range of health effects in adults and children at MeHg exposure levels lower than previously observed (Lynch et al. 2010; Mergler et al. 2007; Oken et al. 2008). In this issue of EHP, Karagas et al. (2012) provide a comprehensive review of the current scientific evidence for effects of low-level exposures to MeHg on birth outcomes, neurocognitive outcomes, the cardiovascular system, and immune function. The authors recommend that future studies investigate sex-specific effects and genetic susceptibility, and that they include more precise exposure indicators, outcome measures with mechanistic bases, and consideration of nonlinear dose–response relationships. Their review helps to set the stage for future research on the human effects of low-level MeHg exposure.

Fish are the most important agents of MeHg exposure for humans, and consumption of contaminated fish is a serious public health concern (Mahaffey et al. 2009; Oken et al. 2005; Sunderland 2007). Currently, all 50 U.S. states have fish advisories for inland and coastal waters, and states on the Atlantic coast, as well as Alaska and Hawaii, have statewide coastal advisories (U.S. Environmental Protection Agency [EPA] 2010). Consumption of marine fish and shellfish is the primary means of human exposure to MeHg; approximately 92% of the global fish and shellfish harvest for human consumption is marine (United Nations Development Programme, United Nations Environment Programme [UNEP], World Bank, and World Resources Institute 2003), with the majority coming from coastal fisheries (Food and Agriculture Organization of the United Nations 2010). Most people trying to reduce MeHg exposure risk do so through their choices in buying and eating seafood. Oken et al. (2012) discuss the wide range of trade-offs facing fish consumers and the difficulties in evaluating current fish consumption advice. Consumers need to consider not only the contaminant concentrations in fish but also their nutritional value, the sustainability of the fishery, and the cost of different fish choices. Moreover, there is little guidance for specific subpopulations with different exposure risks due to factors such as age or baseline intake of fish. The authors recommend that fish consumption advice address these multiple perspectives and provide a clear and simple message. Ultimately, fish consumption advice should protect public health on a global scale and promote sustainability of the world’s fisheries as a critical source of human nutrition.

Currently, important national and international policy decisions are being made concerning the environmental impacts of mercury. The widespread threat to human health posed by MeHg has prompted the United States to pass a mercury rule for controlling atmospheric emissions (U.S. EPA 2011) and the UNEP to forge a broad consensus

**REFERENCES**

Centers for Disease Control and Prevention. 2011. Diabetes Data & Trends. Available: http://apps.nccd.cdc.gov/DDTSTRS/default.aspx [accessed 12 December 2011].

Eyre H, Kahn R, Robertson RM. 2004. Preventing cancer, cardiovascular disease, and diabetes: a common agenda for the American Cancer Society, the American Diabetes Association, and the American Heart Association. CA Cancer J Clin 54:4/190–207.

Janesick A, Blumberg B. 2011. Minireview: PPAR: as the target of obesogens. J Steroid Biochem Mol Biol 127:1–21–4–8.

Kim J, Peterson KE, Scanlon KS, Fitzmaurice GM, Must A, Oken E, et al. 2006. Trends in overweight from 1980 through 2001 among preschool-aged children enrolled in a health maintenance organization. Obesity (Silver Spring) 14(1):1107–1112.

Nadal A, Alonso-Magdalena P, Soriano S, Quesada I, Ropero AB. 2009. The pancreatic β-cell as a target of estrogens and xenoestrogens: Implications for blood glucose homeostasis and diabetes. Mol Cell Endocrinol 304(1–2):83–88.

World Health Organization. 2011. Diabetes Programme: Facts and Figures about Diabetes. Available: http://www.who.int/diabetes/facts/en/ [accessed 12 December 2011].

White House Task Force on Childhood Obesity. 2010. Solving the Problem of Childhood Obesity Within a Generation: White House Task Force on Childhood Obesity Report to the President. Available: http://www.letsmove.gov/sites/letsmove.gov/files/TaskForce_on_Childhood_Obesity_May2010_FullReport.pdf [accessed 12 December 2011].
among 140 participating countries to control mercury contamination through a global, legally binding mercury agreement (UNEP 2009). Moreover, U.S. Senate and House bills have been introduced in order to establish a national mercury monitoring network to track long-term trends in mercury levels in the atmosphere and in terrestrial, freshwater, and coastal ecosystems (Comprehensive National Mercury Monitoring Act 2011a, 2011b). To provide a synthesis of current marine mercury science to inform policy making, C-MERC stakeholders identified the major environmental and health policy questions associated with MeHg, and C-MERC scientists reviewed and summarized the current scientific knowledge available for addressing those questions. In addition to the two articles in this issue of EHP, additional papers will be published in an upcoming special issue of Environmental Research on the fate of MeHg in estuaries, coastal oceans, and the open ocean. The goal of all of these reports is to provide scientists and policy makers with an understanding of the links between environmental processes that affect MeHg levels in aquatic ecosystems and human MeHg exposure and health risks. These links are critical to predicting how local and global changes in environmental mercury levels will ultimately influence MeHg contamination of seafood and the resulting human exposure risk. The author declares she has no actual or potential competing financial interests.

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REFERENCES

ATSDR (Agency for Toxic Substances and Disease Registry). 2011. Detailed Data Table for the 2011 Priority list of Hazardous Substances that Will Be the Subject of Toxicological Profiles. Available: http://www.atsdr.cdc.gov/SPL/resources/ATSDR_2011_SPL_Detailed_Data_Table.pdf [accessed 2 May 2012].

Axelrad DA, Bellinger DC, Ryan LM, Woodruff TJ. 2007. Dose-response relationship of prenatal mercury exposure and IQ: An integrative analysis of epidemiologic data. Environ Health Perspect 115:609–615.

Chen CY, Serrell N, Evers DC, Fleishman BJ, Lambert KE, Weiss J, et al. 2008. Meeting report: methylmercury in marine ecosystems—from sources to seafood consumers. Environ Health Perspect 116:1706–1712.

Cohen JT, Bellinger DC, Shaywitz BA. 2005. A quantitative analysis of prenatal methylmercury exposure and cognitive development. Am J Prev Med 29(4):393–395.

Comprehensive National Mercury Monitoring Act. 2011a. H.R. 3391, 112th Congress, 1st Session. Available: http://www.gpo.gov/fdsys/pkg/BILLS-112s1183is/html/BILLS-112s1183is.htm [accessed 9 May 2012].

Comprehensive National Mercury Monitoring Act. 2011b. S. 1183, 112th Congress, 1st Session. Available: http://www.gpo.gov/fdsys/pkg/BILLS-112s1183is/pdf/BILLS-112s1183is.pdf [accessed 9 May 2012].

Driscoll CT, Han YJ, Chen CY, Evers DC, Lambert KE, Holsen TM, et al. 2007. Mercury contamination in forest and freshwater ecosystems in the northeastern United States. Bioscience 57(1):7–28.

Fitzgerald WF, Labberg GH, Hammerschmidt CR. 2007. Marine biogeochemical cycling of mercury. Chem Rev 107:641–682.

Food and Agriculture Organization of the United Nations. 2010. The State of World Fisheries and Aquaculture 2010. Rome:Food and Agriculture Organization of the United Nations. Available: http://www.fao.org/docrep/013/i1820e/i1820e.pdf [accessed 2 May 2012].

Grandjean P, Cordier S, Kjellstrom T, Weite P, Budtz-Jorgensen E. 2005. Health effects and risk assessments. In: Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes and Human Exposures around the World (Pirrone N, Mahaffey KR, eds). Norwell, MA:Springer, 498–533.

Karagas MR, Choi AL, Oken E, Horvat M, Schoeny R, Kamai E, et al. 2012. Evidence on the human health effects of low-level methylmercury exposure. Environ Health Perspect 120:799–806.

Lynch ML, Huang LS, Cox C, Strain JH, Myers GJ, Bonham MF, et al. 2010. Varying coefficient functional models to explore interactions between maternal nutritional status and prenatal methylmercury toxicity in the Seychelles Child Development Nutrition Study. Environ Res 111:75–80.

Mahaffey KR, Clickner RP, Jeffries RA. 2009. Adult women’s blood mercury concentrations vary regionally in the United States: association with patterns of fish consumption (NHNES 1999–2004). Environ Health Perspect 117:51–53.

Mergler D, Anderson HA, Chan LH, Mahaffey KR, Murray M, Sakamoto M, et al. 2007. Methylmercury exposure and health effects in humans: a worldwide concern. Ambio 36(1):3–11.

Oken E, Choi AL, Karagas MR, Mariën K, Rheinberger CM, Schoeny R, et al. 2012. Which fish should I eat? Perspectives influencing fish consumption choices. Environ Health Perspect 120:790–798.

Oken E, Redekop JS, Wright RD, Bellinger DC, Amasirirawidana CJ, Kleinman KP, et al. 2008. Maternal fish intake during pregnancy, blood mercury levels, and child cognition at age 3 years in a US cohort. Am J Epidem 167:1711–1717.

Oken E, Wright RD, Kleinman KP, Bellinger D, Amasirirawidana CJ, Hu H, et al. 2005. Maternal fish consumption, hair mercury, and infant cognition in a U.S. cohort. Environ Health Perspect 113:1376–1380.

Rice DC. 2004. The US EPA reference dose for methylmercury: sources of uncertainty. Environ Res 99(3):406–413.

Sunderland EM. 2007. Mercury exposure from domestic and imported estuarine and marine fish in the US seafood market. Environ Health Perspect 115:235–242.

UNEP (United Nations Environment Programme). 2009. Overarching Framework: UNEP Global Mercury Partnership. Available: http://www.chem.unep.ch/mercury/Sector-Specific-Information/Docs/Overarching%20Framework.pdf [accessed 3 May 2012].

United Nations Development Programme, United Nations Environment Programme, World Bank, and World Resources Institute. 2002. World Resources 2002–2004: Decision for the Earth: Balance, Voice and Power. Washington, DC:World Resources Institute. Available: http://pdf.wri.org/wr2002_fullreport.pdf [accessed 8 May 2012].

U.S. EPA (U.S. Environmental Protection Agency). 2010. National Listing of Fish Consumption Advisories: Technical Fact Sheet 2010. Available: http://water.epa.gov/scitech/swguide/fishshellfish/fishadvisories/technical_factsheet_2010.cfm [accessed 10 May 2012].

U.S. EPA (U.S. Environmental Protection Agency). 2011. Final Mercury and Air Toxics Standards (MATS) for Power Plants. Available: http://www.epa.gov/airquality/powerplanttoxics/actions.html [accessed 9 May 2012].

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