L.H.M. CHAN

From power to seafood safety: effects of global pollution on our children's health

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TITOLO
Dall'energia alla sicurezza dei prodotti ittici: effetti dell'inquinamento globale sulla salute dei nostri bambini

KEY WORDS
Mercury, seafood safety, global pollution, health

PAROLE CHIAVE
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Professor and BC Leadership Chair
Community Health Sciences Program
University of Northern British Columbia

Address for correspondence:
Laurie Hing Man Chan, Ph.D.
Professor and BC Leadership Chair,
Community Health Sciences Program,
University of Northern British Columbia,
3333 University Way, Prince George,
British Columbia, Canada V2N4Z9
Tel. +1 (250) 960-5237
Fax: +1 (250) 960-5892
E-mail: lchan@unbc.ca

Summary
Mercury is a global pollutant and there is strong evidence that the emission will increase by 50% in 2050. The major source of mercury is from the emission of fuel fossil burning power plants. Mercury accumulates along the aquatic food chain and can reach high levels in fish and shellfish. Mercury is a known neurotoxicant that is particularly harmful to fetal brain development. However, fish and shellfish are widely available food that provides many nutrients, particularly the n-3 polyunsaturated fatty acids (n-3 PUFAs), to many populations globally and there are benefits linked to brain and visual system development in infants and reduced risk for certain forms of heart disease. International efforts are required to control the emission of mercury in the environment. Clear and concise messages on benefits and risks associated with fish consumption choices are required for the general public.

Riassunto
Il mercurio è un inquinante globale e vi è una forte evidenza che le sue emissioni aumenteranno del 50% nel 2050. La principale fonte di mercurio proviene dall'emissione di impianti che bruciano combustibili fossili. Il mercurio si accumula lungo la catena alimentare acquatica e può raggiungere livelli elevati in pesci e crostacei. Questo elemento è un noto neurotossico particolarmente dannoso per lo sviluppo fetale del cervello. Tuttavia, pesci e crostacei sono alimenti ampiamente disponibili che forniscono numerose sostanze nutrienti a molte popolazioni nel mondo, in particolare gli n-3 acidi grassi polinsaturi (n-3 PUFA) che apportano benefici correlati alla sviluppo del cervello e del sistema visivo nei neonati e un rischio ridotto per alcune forme di malattie cardiache. Gli sforzi internazionali hanno l'obbligo di controllo delle emissioni di mercurio nell'ambiente. Sono necessari messaggi chiari e concisi per il grande pubblico riguardo ai benefici e ai rischi associati al consumo di prodotti della pesca.

Mercury (Hg) is released into the environment through both natural and anthropogenic sources and can exist in three forms: elemental, inorganic, and organic. The amount of mercury being released into the atmosphere has been increased by human activities such

as the burning of fossil fuels and municipal waste incineration. Metal mining and smelting, the use of Hg in gold mining, chlor-alkali production, and bio-medical waste are also anthropogenic sources contributing to increased Hg in the environment. Recent studies have found that burning of fossil fuel for power generation plants is becoming a major source of Hg pollution globally. As emission in the form of metallic Hg whose atmospheric residence time is long enough to cause nearly uniform mixing in the hemisphere, much of the impact is global. Sunderland et al. (2008) used sophisticated atmospheric models and estimated that anthropogenic emissions in the US and Canada account for 28-33% of contemporary atmospheric deposition in this region, with the rest from natural (14-32%) and global sources (41-53%). They also suggested that at present atmospheric Hg deposition rates, Hg concentrations in the North Pacific Ocean would double relative to circa 1995 by 2050.

In both freshwater and saltwater ecosystems, the organic form (methylmercury, MeHg) is predominant and has a high propensity to accumulate in fish tissue through ingestion and absorption. Therefore dietary consumption of fish and other seafood including shellfish and molluscs is a major route of mercury exposure amongst human populations. Many populations around the world depend on fish as their major source of food and nutrients. About 20% of the world's population derives at least one-fifth of its animal protein intake from fish, and some small island states depend almost exclusively on fish. The presence of Hg in fish poses a potential threat to their health.

High levels of MeHg exposure have been identified in numerous fish-eating populations throughout the world. Many of these live near oceans, major lakes and rivers or hydroelectric dams and are often dependent on local catch, with fish an integral part of their cultural traditions. For many Northern communities, the problem is often compounded by the consumption of fish-eating marine mammals. Despite the importance of local catch, fish is also a global commodity. In the United States, individuals with elevated blood Hg concentrations have been reported among affluent urbanites, who consume large quantities of marine fish, high in the food web. Thus, elevated MeHg exposure, around the globe, has no geographic, social, economic, or cultural boundaries.

Although most reports on MeHg exposure have focused on specific populations, generally assumed to have high levels of fish consumption and correspondingly elevated levels of MeHg intake, estimates of general population exposure exist for the United States, the EU and Japan. Most studies have identified a clear association between the frequency of fish consumption and Hg exposure.

MeHg is actively transferred to the fetus across the placenta via neutral amino acid carriers during gestation. MeHg accumulates in hair. Hair is often used as biomarker for chronic MeHg exposure. The background level of hair Hg associated with little or no fish consumption or with the consumption of fish with low MeHg concentrations is usually between 0.2 to 1.0 μg/g. Much higher hair Hg levels can result from the consumption of large amounts of fish or sea mammals. In the population of the Faroe Islands, the mean hair Hg level ranges from 1.6 μg/g to 5.2 μg/g. In Indigenous populations from northern Canada, levels higher than 40 μg/g were reported.

Long-term exposure to either inorganic or organic Hg can permanently damage the brain, kidneys, and developing fetus. Organic Hg that is ingested in contaminated fish may cause greater harm to the brain and developing fetus because MeHg readily crosses the placenta and the blood-brain barrier and is neurotoxic. The developing fetal nervous system is especially sensitive to Hg effects. Prenatal poisoning with high dose MeHg causes mental retardation and cerebral palsy. The scientific evidence indicates that exposure to MeHg is more dangerous for young children than for adults. This is because of

the lower thresholds for neurological effects from MeHg and the higher levels of distribution of MeHg to the developing brains of young children, which can result in interference with the development of motor and cognitive skills. Because there are many populations around the world that consume large amounts of fish, epidemiological studies were undertaken in the last two decades to determine whether populations frequently consuming fish were indeed at risk. Their results show that MeHg exposure from the consumption of fish by pregnant women, even at low mercury concentrations (i.e. about 1/10th to 1/5th of the observed effect levels in adults), could/may have subtle, persistent effects on the children's mental development. There is a general association between prenatal MeHg exposure at levels achieved by fish consumption and the child's scores on developmental tests. A study has used dose-response information collected from the cohort studies conducted in the Faroe Islands, New Zealand, and the Seychelles Islands to estimate the relationship between maternal mercury body burden and subsequent childhood decrements in intelligence quotient (IQ), using a Bayesian hierarchical model to integrate data from three epidemiologic studies. They found a central estimate of -0.18 IQ points (95% confidence interval, -0.378 to -0.009) for each parts per million increase of maternal hair mercury, similar to the estimates for both the Faroe Islands and Seychelles studies, and lower in magnitude than the estimate for the New Zealand study.

It is important to note that even though the effects at these dose levels may not seem severe on an individual basis, they may have serious implications for populations. Spadaro and Rabl (2008) estimated that the average global lifetime impact and cost per person at current emission levels are 0.02 IQ points lost and $78.

Because fish is the primary source of Hg exposure among the general population, many governments provide dietary advice to limit fish consumption where there are elevated Hg levels. The World Health Organization and the Food and Agriculture Organization of the United Nations recommend a maximum of 0.5 ppm in non-predatory fish and 1 ppm in predatory fish. The importance of fish consumption for health and nutritional status is immense and it has provided humanity with an essential food source for thousands of years. Fish is a superior protein source to beef, pork, chicken and even milk proteins due to its amino acid profile and ability to support growth. Further, the fatty acid profile of fish differs significantly from the previously mentioned alternative sources of protein: approximately 50% of the fatty acids in lean fish and 25% in fatty fish are polyunsaturated fatty acids (PUFAs).

Maternal intake of fish has also been observed to be valuable to fulfill fetal requirements. Docosahexanoic acid (DHA) is a long-chain polyunsaturated omega-3 fatty acid which is found in lipids from fish and other seafood. This, and other omega-3 fatty acids, may protect against several adverse health effects, and contribute to enhanced cardiovascular health. Further, DHA and arachidonic acid (AA), an omega-6 PUFA, are essential for the development of the central nervous system in mammals. Therefore, during the last trimester of pregnancy, fetal requirements for DHA and AA are very high due to the rapid synthesis of brain tissue. The main source of the DHA and AA that accumulates in the brain is drawn from maternal circulation during pregnancy and through breast milk for newborns. In pre-term and low-birth-weight babies, DHA deficiency has been related to visual impairment and delayed cognitive development. Also, there is some evidence that increased maternal intake of fish or fish oil supplements may prolong gestation in populations where shorter gestation periods are observed.

A number of studies have shown strong evidence that fish or fish oil consumption reduces all-cause mortality and various cardiovascular disease outcomes. Further, a report released by the Scientific Ad-

visory Committee on Nutrition (SACN) of the United Kingdom and the US Dietary Guidelines Advisory Committee (DGAC) states that all adults, including pregnant women, should intake at least two portions of fish per week, of which one should be fatty. This recommendation for consumption of at least two servings of fish per week correlates with improved cardiovascular health.

Results from the major surveys show that only a small portion of the US or Canadian population is heeding the recommendation of including fish at least twice a week in their diet. However, the consumption of Hg from fish in adults who consume the recommended two servings per week of fish may be approaching the threshold levels set by FAO/WHO.

Currently, various organizations provide advice or recommendations concerning fish consumption. Some health agencies issue advice about maximum acceptable consumption with the objective of protecting the population from the risks associated with contaminants exposure whereas others present their recommendations in terms of minimal recommended consumption in order to decrease the cardiovascular disease risks and of non-optimal development of the nervous system of the child, the two identified beneficial effects associated with n-3 fatty-acids. These two seemingly contradictory messages are thus transmitted to the public, which can cause confusion. The World Health Organization and the Food and Agriculture Organization convened a special Expert Panel to assess the risks and benefits of fish consumption in January 2010. The final report was expected to be released in June 2011. Hg is a global pollutant. Fish can accumulate high level of Hg emitted from industrial sources that are thousands of kilometers away. Environmental changes such as global warming, soil erosion due to deforestation, and building of hydro dams can increase the methylation or bioavailability of Hg. Many of the fish species found in "unpolluted" water bodies far from point-source industrial emissions have Hg levels that are not safe for sustained human consumption. This can have major health impacts on local human populations as fish often comprises an important part of their diets. International efforts are needed to control the emission of mercury. Public health interventions need to balance the risk against the benefits of fish consumption including cultural values.

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