CURRENT ISSUES
THE INSIDE STORY

Methylmercury intake and Fish Consumption by Pregnant Women, Women of Childbearing Age, and Young Children

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Summary:
Mercury and its biological form methylmercury (MeHg) is a potent toxin in our food supply, found almost exclusively in fish and shellfish. It is a persistent organic pollutant in the environment and accumulates in organisms that ingest it. Mercury is designated a "toxic substance" under the Canadian Environmental Protection Act (CEPA) (10). Regulation of, and advisories about, mercury in fish are federal and provincial responsibilities.

Recent studies report that methylmercury is now present in certain fish in higher amounts than previously indicated (24). In the US general population, approximately 8% of pregnant women have cord blood mercury levels at or above the upper safe limit (3, 24). In Canada and in the USA, fish consumption is increasing (39d). In response to this new information, the American Environmental Protection Agency and Food and Drug Administration updated their advisory to the public in March 2004 (12). Health Canada is reviewing the issue at the current time.

What are the sources of methylmercury?

Mercury exists in nature, but human activities have resulted in massive mobilization into the global ecosystem. Globally, approximately 2,200 tons of inorganic mercury are released annually into air, water and soil each year from the combustion of fossil fuels (70% from coal-fired power plants), industrial and mining sources, waste incineration, mercury-based seed-treatment fungicide use, and dumping or burning of products containing mercury (23, 36, 41).

Once released into the atmosphere, mercury can travel long distances with prevailing winds. When it is deposited in lakes, rivers and oceans, aquatic microorganisms transform it into methylmercury (MeHg), its organic and most toxic form. MeHg bio-accumulates up the food chain, first in smaller marine animals and fish, and eventually in larger predatory fish where it can be concentrated many thousand-fold. MeHg is stored in the muscle part of fish, therefore trimming the fat from fish does not reduce mercury concentration.

Toxicokinetics of methylmercury

Consumption of fish and marine mammals is the single most important source of human exposure to methyl mercury. About 99% of mercury in fish is MeHg. In the human digestive tract, about 95% of MeHg in food is absorbed (38). MeHg accumulates in animal and human tissues faster than it is excreted (its half-life is about 50 days). As it is water soluble (21), it passes through the blood-brain and placental barriers, and becomes more concentrated in the fetus than the mother (35). The fetal brain is more susceptible than the adult brain to MeHg-induced damage. In the brain, mercury inhibits the division and migration of neuronal cells (5, 42). Once in the central nervous system, MeHg can be demethylated to inorganic mercury, which persists even longer in the body.

MeHg binds to red blood cells, is deposited in almost all tissues, and can be measured in maternal blood, cord blood, breast milk, hair, and nails. Among pregnant women in South Western Quebec, a strong dose relation was observed between frequency of fish consumption before and during pregnancy and MeHg in maternal hair and cord blood (32). Cord blood MeHg is approximately twice as high as maternal blood in late pregnancy (43). Adverse effects in children are believed to occur when the pregnant mother's blood mercury level is more than 15 micrograms per liter (ug/L). The concentration of mercury in breast milk is approximately 5% of the mother's blood mercury concentration (7). After stopping or reducing consumption of fish high in mercury, blood levels gradually decline over a period of months (25).

Health outcomes of methylmercury ingestion

Traces of mercury are found naturally in organic tissues without consequence, but chronic intake of larger amounts results in toxicity. Fetal exposure to MeHg is of special concern, since it causes the destruction of neural cells in the developmental stage.

Strong scientific evidence comes from international human epidemiological studies, that certain levels of MeHg exposure in utero are associated with irreversible, neurological problems in infants and children (8, 18, 28, 34, 40, 42). Outcomes range from poor performance on tests that measure attention, visual-spatial ability, motor function and language (e.g. delayed walking and speech). With high exposures blindness, deafness, seizures, cerebral palsy and death have been observed (29). These studies have formed the basis for setting standards for mercury exposure. In Canada in 2003, increased incidence of cerebral palsy among male infants in the Great Lakes basin was hypothesized to be related to elevated levels of mercury in the basin (16).
In older children and adults, chronic and/or high mercury

CURRENT ISSUES
THE INSIDE STORY

exposure has reproductive, neurological, renal, cardiovascular and immunological impacts (19, 34). Symptoms of chronic or high MeHg exposure include memory loss, decreased concentration, tunnel vision, fatigue, muscle and joint pain, and impairment of immune, cardiovascular and reproductive systems, including delayed time to pregnancy (24, 25).

Methylmercury in humans

The most recent and most widely accepted "upper safe limit" of total mercury in human blood is **5.8 ug/L or ppb** (35). This blood concentration is associated with an average dietary intake of **0.1 ug MeHg/kg body wt/ day**, called the "reference dose". It was derived from evidence of developmental effects from *in utero* MeHg exposure in the Faroe Islands study (18), and includes a 10-fold dilution factor for safety.

The amount of MeHg actually found in humans varies greatly, depending on the amount and type of fish consumed. Most population-wide assessments have yielded blood levels well below this level. However, subpopulations, such as northern Aboriginal communities, Great Lakes fishers and eaters of Asian descent (6, 33, 41), and a sample of "high-end" fish consumers in California have shown blood mercury levels considerably higher than this (25). In the USA, NHANES data showed that 7.8% of women age 16 – 49 may have blood mercury levels above the upper safe limit (3, 24). Equivalent Canadian data are not available.

Methylmercury in fish

(a) Canadian Food Inspection Agency (CFIA), 2003

In terms of mercury levels in commercial fish, Health Canada has set the upper safe limit at 0.5 ug *total mercury* per gram of fish (or ppm) sold in Canada. This is called the "action level". This limit does not apply to large predatory fish, however, as these are known to regularly exceed the upper safe level. Instead, an advisory exists on the CFIA website.

The CFIA tests for mercury in commercial fish and seafood destined for retail in Canada (**www.inspection.gc.ca**) though the amounts of mercury found in commercially-sold fish is not publicly available.

Shark, swordfish and fresh tuna are rarely tested because they are known to be high in MeHg. Five percent of canned tuna shipments (as well as marlin, sea bass and mahe mahe) have a random sample tested for mercury content. If these are found to contain more than 0.5 ppm mercury, the fish cannot be sold. The CFIA website states: "It is important to note that this exemption does not apply to canned tuna. The species used in canned tuna tend to be smaller and shorter lived than those used in the fresh and frozen market; therefore, the level of mercury found in canned tuna tends to be lower than that of fresh and frozen tuna.

Yet, the larger albacore or yellowfin tuna (labeled "white" on cans) are considerably higher in mercury, with samples on the upper end of the range exceeding the action level. According to information sent by the CFIA laboratory in BC, canned albacore tuna in 2002 averaged 0.37 ppm – just below the action level. Samples ranged from 0.18 to 0.64 ppm. Size of yellowfin tuna varies from 40-180 cm and weight varies from 5-20 kg (44). This is reflected in the wide range of MeHg values that are recently found in yellowfin tuna sold retail (45). Skipjack tuna, labeled as "light" on cans, is generally smaller and therefore lower in mercury. According to CFIA data, Canada, yellowfin and skipjack tuna average only 0.05 ppm and 0.06 ppm mercury respectively. This is well below the action level.

In the past, it was understood that tuna labeled "light" on cans included only smaller, lower mercury fish. Recently, the fishing industry has conceded that "light" canned tuna (especially "chunk light") could also include yellowfin tuna, which can be large in size and consequently can be as high in methylmercury as albacore. Therefore, it is important that consumers, especially pregnant and lactating women, women who could become pregnant and parents/caregivers of young children, be alerted to look on the label for skipjack tuna.

(b) Ontario Ministry of Natural Resources,
Guide to Eating Ontario Sport Fish, 2005-06 (17)

The amount of mercury in Canadian fresh water fish are also not publicly available. The Ontario Ministry of the Environment issues a Guide which indicates with a symbol the species of fish that have a mercury content high enough to be unacceptable for human consumption.

(c) US Food and Drug Administration (FDA)

In the US, since 1999, there was a moratorium on testing of mercury in seafood by the FDA. Most mercury testing is done and paid for by the fishing industry and is therefore proprietary information. The FDA website, Center for Food Safety & Applied Nutrition, Office of Seafood (13) provides a mixture of old and new (1978-2002) data on mercury in fish. It indicates that large predatory fish (Tilefish, King Mackerel, Swordfish, Shark and Marlin) contain 0.5 – 1.45 ppm of mercury. Albacore or bluefin tuna (fresh, frozen, canned) contain .35 - .38 ppm

mercury on average. Other fish, including "light" tuna (yellowfin, skipjack, tongol) contain lower amounts. See **http://www.cfsan.fda.gov/~frf/sea-mehg.html**

Nutritional benefits of fish

Fish are an excellent source of high-quality protein and long-chain omega-3 fatty acids (alpha-linolenic acids, EPA, DHA), essential for optimal brain, retinal and cardiovascular development (30). They are also low in saturated fat compared to meat and poultry, and are a source of selenium, vitamins D and A and calcium (if

CURRENT ISSUES
THE INSIDE STORY

bones are eaten). In 1999, the US EPA and TERA (Toxicology Excellence for Risk Assessment) produced a detailed report, *Comparative Dietary Risks: Balancing the Risk and Benefits of Fish Consumption* (11). The report provides data on the nutritional content of several types of fish, including omega-3 fatty acids. The authors developed a framework to estimate the relative risk, resulting in a **Fish Consumption Index.** They concluded that "consuming fish that are smaller, younger or proven less contaminated may provide health benefits with minimum health risks". They also pointed out, however, that significant gaps in information (especially contaminant content) currently prevent accurate estimates of benefits and risks for a larger range of fish.

The Heart and Stroke Foundation of Canada encourages people to eat fish regularly, and advises that women of childbearing age who are concerned about possible mercury contamination should eat smaller, canned fish like sardines, mackerel or salmon. A 2002 American Heart Association "scientific statement" summarized recent epidemiological evidence about the effects of omega-3 fatty acids on cardiovascular disease. Due to the substantial benefits, the AHA recommends eating 2 servings of fish per week. They also note that "the extent to which MeHg in fish may diminish the beneficial effects of omega-3 fatty acids requires further study" (20, 27).

A 2004 British report on fish consumption, produced jointly by COT (Committee on Toxicity) and SACN (Scientific Advisory Committee on Nutrition), strongly recommends the addition of one portion oily fish per week per person, to increase the intake of long-chain fatty acids (especially DHA) and reduce the risk of heart disease (15). A study published that same year, with 11,585 pregnant women in SW England, showed that the incidence of intra-uterine growth retardation (IUGR) decreased with increasing fish intake (37).

Fish are an important part of the diet of many cultures. Some types, like canned tuna, are an inexpensive and nutrient-dense part of the diet, which is especially important for low-income families. Canned fish is one of the nutritionally healthier foods commonly supplied by food banks, a source of high quality protein and essential fats which is not easily replaced.

Fish Advisories

(a) Advisories for Marine Fish and Seafood

Health Canada, 2001 (22): Reference dose (maximum recommended intake) is 0.20 ug /kg /day for pregnant women, women of childbearing age and children under15 years. Advisory: "Limit 1 meal/ month shark, swordfish, fresh/frozen tuna. All other fish can be consumed freely".

U.S. EPA/ FDA, 2004 (12): Reference dose is 0.10 ug /kg /day. Advisory to pregnant women, women of childbearing age and children under15 years is: "Do not eat shark, sword-fish, king mackerel, tilefish. Eat up to 12 oz. (2 average meals) per week of a variety of fish & shellfish that are lower in mercury. You may eat up to 6 oz. (1 average meal) of albacore tuna per week as part of your 2 fish meals per week."

(b) Advisories for Inland Sport Fish

Canadian information regarding sports fish advisories is available on the Environment Canada website at **http://www.on.ec.gc.ca/laws/tenth-ijc-response/threats-e.html**

The Guide to Eating Ontario Sport Fish (17) provides information in the form of maximum number of meals of each fish that are recommended for the general public and for pregnant women, women of childbearing age, and children under 15. A two-page pamphlet summarizing the Guide is available in 15 languages. Quantities can be ordered from the Sport Fish Contaminant Monitoring Program (sportfish@ene.gov.on.ca).

In March, 2000 the Fish and Wildlife Nutrition Project released a report for Health Canada, "*Communicating Fish Advisory Information: A Monograph*" (14). The researchers found little evidence that the *Guide to Eating Ontario Sport Fish* was used as intended, namely to determine the maximum number of meals of particular fish people should consume per month.

How much fish do people eat?

In Canada, fish consumption in 2002 was estimated at just over 7 kg per person (39d). This is 16.4% higher than a decade earlier. Reasons cited by Statistics Canada were "a wider array of convenient and easy-to-prepare products and a demand for alternate sources of protein." Fish consumption by type and by demographic subgroups is not available in Canada.

Application of standards and estimated level of risk

The following examples illustrate how weekly consumption of albacore tuna would lead to an intake of MeHg that closely approximates the US (EPA) or Canadian (HPB of HC) reference doses.
These calculations assume that one 120g can of albacore tuna, with the average mercury concentration of .37 ppm, contains 43 ug of mercury per can. Thus:

- If a 140 pound (64 kg) woman eats 1 can of albacore tuna per *week*, she would consume the equivalent of 0.1 ug mercury/kg/*day* (equal to EPA's reference dose, or half of Health Canada's reference dose).
- If a 70 pound (32 kg) child eats 1 can of albacore tuna per *week*, he/she would consume the equivalent of 0.2 ug mercury/kg/*day* (twice the EPA's reference dose, or equal to Health Canada's reference dose)

CURRENT ISSUES
THE INSIDE STORY

These amounts become proportionately higher when the child or woman is smaller (but eats the same amount), or when the fish contains a concentration of mercury closer to the upper range, and when other sources of mercury are consumed in addition to this weekly serving.

Recommended actions

(a) Pre-pregnancy Screening: Because adverse effects in children are believed to occur when the pregnant mother's blood mercury level is more than 15 ug/L, pre-pregnancy screening is important for people who eat fish frequently (25).

(b) Dietary surveillance of Canadians

(c) Fish testing by government labs (rather than by industry), and greater availability of data (2, 9, 11, 25, 31)

(d) Public awareness through labeling or signage: Many groups, including the California Medical Association, urge that information and advisories resulting from further testing be made readily available to consumers where fish are sold (1).
(e) Fish consumption advisories for marine fish, seafood and sports fish consumption in Canada that reflect current average concentrations of methylmercury and current consumption levels of groups that consume fish frequently.

(f) To avoid chronic accumulation of methylmercury, pregnant women, those who could become pregnant, women who are breastfeeding and young

children should avoid shark, swordfish, king mackerel, tilefish and fresh or frozen tuna because these fish contain high levels of mercury. Adult at risk groups may include up to 340 g (12 ounces) or two average meals per week of a variety of fish and shellfish that are lower in mercury; young children should be offered age-appropriate portions. Five of the most commonly eaten low mercury fish include shrimp, canned light tuna (specifically labelled as skipjack), salmon, pollock or catfish. Albacore ("white") tuna has more mercury than canned light skipjack tuna. So, when choosing the two meals of fish and shellfish a week, pregnant women, those who could become pregnant and women who are breastfeeding may eat up to 170 grams (six ounces) of albacore tuna (one average meal) per week; young children should be offered age-appropriate portions. Large-sized tuna contains more mercury than small-sized tuna. Yellowfin canned tuna may have a higher mercury content than skipjack tuna if large-sized tuna are used. Cans of tuna, even "light" tuna which do not state a specific species of fish on the label, could contain large-sized tuna, such as yellowfin tuna.

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CURRENT ISSUES
THE INSIDE STORY

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CURRENT ISSUES
THE INSIDE STORY

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