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METHYL MERCURY

INTRODUCTION

Mercury is a pollutant of particular concern because, once biotransformed to methyl mercury by microorganisms in marine or aquatic sediments, it readily enters the food chain and is biomagnified in predatory animals. Methyl mercury is readily absorbed and distributed throughout the body, and it is found in the human brain in concentrations six-fold higher than blood concentrations. It readily crosses the placenta and appears to accumulate in the fetus. Methyl mercury levels are measured in hair and blood; a 50 ppm hair mercury level is equivalent to a 200 ppb blood mercury level. From the data from an outbreak of methyl mercury poisoning in Iraq, the WHO concluded that a 5% risk of minimal effect in offspring may be associated with mothers' hair mercury levels of 10-20 ppm. Women whose diets are high in fish may exceed this level.

A number of epidemiological studies have been conducted in populations exposed to mercury through food contamination incidents or through consumption of fish or fish-eating animals. The most recent reports come from a large study in the Seychelles Islands.

A monthly review and summary of the scientific literature on human health effects and environmental pollutants, with an emphasis on pollutants of the Great Lakes ecosystem. Prepared under the direction of the Health Professionals Task Force of the International Joint Commission. This report does not represent the official position of the International Joint Commission.

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The tragic consequences of mercury on fetal development have been seen in previous mercury poisoning incidents in Iraq and Japan. The first report of human poisoning in the Minamata area of Kyushu, Japan, occurred in 1953. Consumption of methyl-mercury contaminated fish was found to be the cause, and mercury discharges to Minamata Bay were banned in 1968. In addition to the acute effects in adults and children, congenital cases of a cerebral palsy-like illness began appearing. Forty children were registered as having severe congenital Minamata disease. The childrens' mothers often showed only mild signs of organic mercury poisoning.

In a 1960 outbreak of methylmercury poisoning, an estimated 1000 Iraqi people[2,3] were affected by consumption of methylmercury-treated wheat seed that was sold for human consumption. In a study of 32 children who were exposed in utero, 9 died before reaching 3 years of age, 10 had cerebral palsy, 3 had microcephaly (unusually small brain), and a substantial number of the children with no initial symptoms showed delayed psychomotor development by 5 years of age.

Testing conducted in 1975-9 in other fish-eating communities by Japanese scientists[4] indicates that methyl mercury poisoning was not limited to the residents living in Minamata. Hair mercury levels were increased in villages along the coast of Shiranui Sea, with means ranging from 29 to 51 ppm (39 ppm in Minamata), which far exceed the mean of 2.3 ppm found in a nonpolluted Japanese community. Neurological exams were conducted on residents of a village across the sea from Minamata (whose diet relied on fish from Shiranui Sea) and residents of a village that relied on nonpolluted coastal fish. Five clinical signs were selected to represent neurological deficits. In Ooura, 56.2% of the subjects had more than one of the five neurological signs, and 15.7% had more than three signs. In the control village, only 9.2% had more than one neurological sign, and none had more than three signs. The most common neurological sign was sensory disorder, particularly a decreased sensation at the distal part of the hands and feet ("stocking and glove").

RISK ASSESSMENT

In a recent review of human and animal studies on developmental effects of methyl mercury, Gilbert and Grant-Webster (1995)[5] recommend that the accepted reference dose guidelines for methyl mercury should be lowered to 0.025-0.06 ug/kg/day. The current U.S. reference dose (RfD) for methyl mercury is 0.3 ug/kg/day, which is equivalent to consumption of 19 ug/day for a 62 kg women, and the WHO guideline is 0.47 ug/kg/day in adults. From their review of human studies, the authors conclude that maternal hair mercury levels of 10 to 20 ppm (about 40-80 ppb blood mercury concentration) are potentially harmful to fetal development. Using an assumption from previously developed kinetic models that daily consumption of 1 ug of mercury will result in 1 ppb blood mercury concentration and a 10-fold uncertainty factor, the authors calculate a NOAEL (no observable adverse effect level) or RfD of 0.06 ug/kg/day. Similarly, a RfD of 0.025 ug/kg/day was calculated from animal studies results.

In contrast, scientists at ICF Kaiser and the Electric Power Research Institute[6] used an alternative risk assessment methodology, the Benchmark Dose Model to reassess the recommended mercury consumption limits. Using the NOAEL for the most sensitive indicator of developmental effects in the New Zealand study (about 17 ppm mercury in maternal hair) the authors recommend that the RfD could be increased, by a factor of 3 to 8, from the current 0.3 ug/kg/day to 0.8-2.5 ug/kg/day.

COHORT STUDIES

CANADIAN CREE INDIAN COHORT STUDY

In a 1985 study of Cree Indians[5] from communities in North Quebec with known high organic mercury exposure in the diet, over 200 children born in 1975-6 were examined using both neurological and developmental tests. Maternal hair mercury levels were used to estimate the childrens' mercury exposure, and the mean methylmercury level was approximately 6 ppm. Only 6% of the children had exposure levels exceeding 20 ppm. Abnormality of the tendon reflexes was positively associated with methyl mercury exposure only in boys (p=0.05), but there was no consistent dose-response relationship. No other positive associations were found.

FAROE ISLANDS STUDY

Philippe Grandjean and colleagues[7] collected umbilical cord blood and maternal hair samples in a cohort of approximately 1000 children born in 1986-7 in the Faroe Islands, where fish and whale meat and blubber are main diet components. The median maternal hair mercury concentration was 4.5 ppm, and the median umbilical cord blood mercury concentration was 24.2 ppb[8]. Surprisingly, higher mercury concentration was found to be associated with increased birth weight, possibly due to confounding by positive effects of fish consumption. Mercury was also negatively associated with alcohol consumption[10]. As a measure of childhood development, district health nurses completed 583 questionnaires on milestone development during the first year of life[9]. Three of the milestones (sitting without support, creeping, and standing without support) were reached by all children before 12 months of age, and were used in an analysis of developmental effects of mercury. The age at which a child reached a developmental milestone was not associated with prenatal mercury exposure levels (maternal hair or umbilical cord blood). Surprisingly, mercury levels measured in infants' hair at twelve months of age were positively associated with milestone development. Milestone development was also associated with length of breastfeeding, and the authors conclude that any potential adverse effect of mercury on milestone development was compensated for or overruled by advantages associated with nursing.

NEW ZEALAND STUDY

Researchers in Sweden[11] conducted a study of neurological effects resulting from prenatal methyl mercury exposure in New Zealand. From an initial review of 11,000 mother-child pairs, a cohort of 73 children whose mothers' hair methylmercury levels exceeded 6 ppm (range 6-86 ppm) was selected and matched with control children. At 4 years of age, developmental effects in 31 offspring were assessed using the Denver Development Test. Abnormal or questionable results were found in 50% of the study children, as compared to 17% of the control children. In 1985, 61 of the offspring (now 6-7 years old) were contacted and further assessments were made, and the results confirmed the findings from earlier testing. The authors concluded that an average hair mercury level of 13-15 ppm may be associated with decreased test performance.

SEYCHELLES CHILD DEVELOPMENT STUDY

The Seychelles Islands, where oceanic fish are a substantial part of the diet, is the site of a study by a team of researchers from the University of Rochester.[12,13,14] A pilot cohort study was conducted with approximately 800 mother-child pairs, beginning in 1987, and the main study was initiated in 1989, again with about 800 mother-child pairs. The mercury level in maternal hair samples serves as an estimate of the child's prenatal mercury exposure; the median maternal hair mercury level was 5.9 ppm (range 0.5 to 26.7 ppm).

A series of neurological and behavioral tests were conducted at various stages in the development of these children. At six and one half months of age, the Fagan test of visual recognition, the Denver Developmental Screening Test-Revised and a neurological examination were performed on the children in the main study.[12] No association was found between maternal mercury levels in hair during pregnancy and adverse neurodevelopmental outcomes; however, it was noted that males had lower scores on visual recognition and visual attention tests, which would support the findings of the Canadian study.

At 19 and 29 months of age, children from 738 mother-child pairs in the main study were evaluated with the Bayley Scales of Infant Development and the Bayley Infant Behavior Record.[13] Only one subjective endpoint was correlated with prenatal exposure to mercury; on the Bayley Infant Behavior Record, activity level in boys, but not girls, decreased with increasing mercury exposure. The authors concluded that the decreased activity level may represent a subtle influence of mercury on behavior without detectable residual effects on cognition.

Results were also presented from a subset of children in the pilot study, in which 217 children were evaluated at 66 months of age, using the McCarthy Scales of Children's Abilities, the Preschool Language Scale and tests from the Woodcock-Johnson Tests of Achievement.[14] Scores on four of the tests were significantly associated with methyl mercury level in utero. These tests included general cognitive abilities, auditory comprehension and language comprehension. After adjustment for outliers, only auditory comprehension remained significant. The authors intend to study these associations in more detail in the main study.

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EXPOSURE STUDIES

* A survey of mercury exposure in a gold-mining area in Brazil[15] found higher mercury blood levels among the fish-eating villagers living along a mined river (mean 31.3 ppb) than in less-exposed residents of other villages (9.3 and 2.0 ppb in two villages).

* A study in a mining community in Papua New Guinea[16] found that hair mercury levels were significantly higher ($p<0.0001$) in the population living downstream from a mining area (mean 1.2 ppm) than upstream (mean 0.55 ppm) due to the consumption of mercury-contaminated fish.

* Researchers at Health Canada[17] recently reported data from mercury exposure studies of people in 514 Native American communities in Canada, who have been found to have high exposures to pollutants through the diet. Of this group, 23% had blood mercury levels above the acceptable level (20 ppb, or 6 ppm in hair) and 1.6% were considered to be "at risk" with mercury levels exceeding 100 ppb (30 ppm in hair).

* Health Canada researchers[18] estimate a total exposure for adults of 7.7 ug/day (0.11 ug/kg/day), and an absorbed dose of 5.3 ug/day (0.076 ug/kg/day) for the general Canadian population. Fish consumption was found to represent 40% of the absorbed methyl mercury dose, while dental amalgam was indicated as the source of 37% of the total mercury dose, or 42% of the total absorbed dose.

* Researchers in Denmark[19,20] found mean blood levels of 14.9 ppb (range 2-128) and 21.0 ppb (range 2-136) in maternal and umbilical cord blood samples from the Inuit population of Greenland who rely heavily on whale meat in the diet.

* University of Miami[21] researchers found a mean hair mercury level of 3.48 ppm (range 1.26-15.57 ppm) among three groups — Native Americans, sport and subsistence fishermen, and Everglades residents — living near the Florida Everglades, who reported a relatively low intake of fish (average 1.79 meals/week).

* Scientists at the Universita di Siena, Italy[22], investigated methyl and total mercury exposure in residents of a fishing village in Portugal, whose diet included at least 3 fish meals per week. Mean levels of total mercury in hair (for men and women, respectively) were 39.76 ppm and 16.22 ppm and mean methyl mercury levels were 36.25 ppm and 15.59 ppm. Citing earlier studies that indicated a 5% risk of neurological effects in adults with hair methyl mercury levels exceeding 50 ppm, the authors noted that 36% of fishermen had methyl mercury levels above 50 ppm. In addition, 87% of the women had hair methyl mercury levels above 6 ppm, which may pose a risk for their children. Further study of neurological effects in these children is underway.

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