Blood Mercury Levels and Fish Consumption in Louisiana

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The primary source of non-occupational exposure to mercury is through the consumption of contaminated fish. Since 1994, the Louisiana Department of Environmental Quality has reported mercury contamination in fish obtained from bodies of water throughout the state and has issued fish consumption advisories accordingly. To determine the extent of mercury intoxication in Louisiana, screening for blood mercury levels was offered to volunteers residing near selected advisory areas. A total of 313 residents participated in the screening; 6 were found to have elevated levels. No level was detected in 48 of the participants, while the remaining participants had normal levels. Significantly higher levels were found in those associated with commercial fishing and those reporting increased fish consumption. For most people, ordinary consumption of fish contaminated with mercury does not currently appear to pose a public health hazard in Louisiana; however, educational efforts regarding the risks of fish consumption in great quantities should be continued.

Whether from natural sources such as mineral deposits, oceanic emissions, and volcanic eruptions, or from human activities such as mining, combustion of fossil fuels, and industrial emissions, mercury is a substance present everywhere in the environment. Methyl mercury, the most common organic form of mercury, is produced when microorganisms in the soil and water interact with inorganic mercury. Because it has a high affinity for protein sulfhydryl groups,[1] methyl mercury accumulates in organisms and is enriched along the food chain.[2]

While terrestrial food is a negligible source of methyl mercury for the general population, certain aquatic species, particularly large predatory fish, accumulate this organic form of mercury in liver, kidney, brain, and muscle tissues.[3] Thus, the primary source of non-occupational exposure to mercury for humans is through the consumption of contaminated fish.[4]

The potential for mercury toxicity in Louisiana residents is a legitimate concern for two reasons. First of all, fish is a main dietary component in this state and much of the fish consumed is caught in local waters. Secondly, the Louisiana Department of Environmental Quality has reported the presence of mercury in fish obtained from local bodies of water. Since 1994, this department has conducted annual testing in more than 100 bodies of water throughout the state. The edible portions of the fish tested were found to have mercury contamination in all tested areas. Advisories regarding the consumption of mercury contaminated fish have been issued by the Louisiana Department of Health and Hospitals, the Louisiana Department of Environmental Quality, and the Louisiana Department of Wildlife and Fisheries (Appendix).

Louisiana is not facing this problem alone. In 1992, the state of Arkansas began creating similar advisories after discovering mercury levels in local fish exceeded the Food and Drug Administration (FDA) tolerance limits.[5] To determine the extent of mercury intoxication, the Arkansas Department of Health provided baseline blood mercury screening to volunteers who lived in eight affected counties. Two hundred thirty-six participants, who confirmed their fish consumption was a minimum of two meals per month of fish caught in the lower Saline or Ouachita Rivers, were tested. Fifteen percent of those tested were found to have blood mercury levels in the elevated range of 20-75 parts per billion (ppb), while 25% were found to have no detectable blood mercury levels.[6]

Increasing public awareness of the presence of mercury in our environment and the potential for toxicity has prompted the Louisiana state legislature to follow in Arkansas' footsteps and provide similar screening for elevated blood mercury levels in residents living near selected advisory areas. This screening is essential to determine the extent of mercury intoxication in Louisiana residents and to evaluate the potential health risks of consuming contaminated fish caught in local waters.

In this article, we review the historical and toxicological considerations of mercury poisoning and discuss the results of this screening with regard to age, occupation, race, education, frequency of fish consumption, and pregnancy.

Historical Considerations

Mercury was first used medically to treat syphilis in the late 15th century.[7] Gradually, its toxicity became known and by the 19th century it was generally accepted as toxic and its medicinal use was markedly decreased. The toxicity of mercury was brought to the attention of the scientific community by its use in industry. In 1863, Frankland and Duppa used dimethyl mercury to determine the valency of metals and metallic compounds.[8] Later that year, two laboratory technicians participating in the study died of mercury intoxication . Consequently, mercury's toxicity became well known among chemists; however, physicians did not appreciate the potential for mercury intoxication until an industrial accident brought it to the forefront. In 1940, four industrial workers were hospitalized with methyl mercury poisoning as a result of an industrial accident.[10] In 1950, one of those workers died; the subsequent autopsy revealed destruction of neurons with cerebral and cerebellar atrophy. These pathological findings along with the presenting symptoms of progressive ataxia, impaired speech, and constricted visual field became known as Hunter-Russell syndrome and methyl mercury was designated the etiologic agent.[11]

Meanwhile, in the early 1950s, the Chisso Corporation chemical factory was discharging its waste effluent, contaminated with methyl mercury, into Minamata Bay in Japan--a common practice at the time . A disease similar to Hunter-Russell syndrome merged, but it also presented with deafness and sensory abnormalities. Minamata Disease, as it was named, was not officially recognized by the Japanese government as being caused by environmental pollution with methyl mercury until 1968.[12] More than 2,250 patients have been officially recognized as having Minamata Disease, 1,043 of whom have died.[13] The number of unofficial sufferers is believed to be much greater.

A second epidemic of mercury poisoning occurred in 1976 in Iraq. More than 6,000 people were affected when they consumed bread made from grain treated with methyl mercury fungicide. At least 500 of those people died as a result of the intoxication.[14] Similar episodes have occurred with seed grain contaminated with methyl mercury in Guatemala[15] and Pakistan.[16]

Several regulations have been established regarding methyl mercury since these outbreaks have occurred. In 1973, an allowable mercury concentration in fish was established by Japan's Ministry of Health and Welfare--total mercury at 0.4 µg/g and methyl mercury at 0.3 µg/g.[17] Government authorities also established that there should be no detectable mercury or methyl mercury in industrial waste water.

In the United States, the FDA established an action level of 1 ppm methyl mercury; commercial fish and shellfish, as well as treated seed grain, sold through interstate commerce found to have levels exceeding 1 ppm cannot be sold to the public. The Environmental Protection Agency (EPA), in conjunction with the FDA, has set a limit of 2 ppb inorganic mercury in drinking water. The EPA also currently recommends the level of inorganic mercury in rivers, lakes, and streams should be less than 144 parts per trillion (ppt) to protect human health.[18]

Toxicological Considerations

The critical organ system affected in humans by methyl mercury is the central nervous system. Mercury is a neurotoxic agent, affecting primarily the occipital cortex and cerebellum.[19] Methyl mercury poisoning is evident with low levels of exposure and presents most commonly with nonspecific signs and symptoms, including paresthesias, ataxia, constriction of the visual field, and impairment of hearing.[20] With prolonged daily methyl mercury intake of 3-7 µg/kg body weight, the incidence of poisoning is 5%.[21]

Prenatal exposure to high-dose methyl mercury is particularly devastating and can cause mental retardation and cerebral palsy in the newborn. In all cases of reported fetal methyl mercury poisoning, the source was dietary; however, only in Minamata and Niigata, Japan, was fish consumption involved.[22] The fish consumed in these areas contained very high methyl mercury levels secondary to local waterway pollution. Consumption of fish with low levels of methyl mercury, below 1 ppm, during pregnancy has not been shown to place the fetus at neurodevelopmental risk.[23]

The International Commission of Occupational Health and the International Union of Pure and Applied Chemistry Commission on Toxicology have determined the average baseline whole blood level of mercury to be approximately 2 ppb in people who do not eat fish.[24] In people who do eat fish, a normal blood level of mercury is between 2 and 20 ppb. Levels greater than 20 ppb are considered elevated and it is recommended that those people decrease fish consumption. Levels greater than 80 ppb in the general population[25] and 40 ppb in children and pregnant women[26] need medical evaluation, as well as decreased consumption of fish. Levels greater than 200 ppb are associated with a 5% incidence of poisoning.[27] This level results from chronic daily methyl mercury intake of 3-4 µg / kg body weight for at least 1 year.[28]

Screening Protocol

From February to March of 1998, the State Office of Public Health offered free blood mercury screening through local parish health units to residents in thirteen parishes, including Acadia, Caldwell, Evangeline, Iberia, Jefferson Davis, Lafayette, Morehouse, Ouachita, St Landry, St Martin, St Tammany, Vermilion, and Washington parishes. Participants also completed a written questionnaire regarding risk factors for mercury poisoning.

Whole blood samples, collected by venipuncture, were analyzed by cold vapor atomic absorption in the Office of Public Health Central Laboratory, New Orleans, Chemistry Section. This laboratory complies with the quality control procedures recommended by the Center for Disease Control and Prevention (CDC). The limit for detection of blood mercury is 0.30 ppb.

Residents believed to be at high risk were specifically targeted for this screening. Women who were pregnant, breastfeeding, or had small children were informed of the screening through the Women, Infants, and Chldren Supplemental Food Program (WIC). Commercial fisherman and charter boat captains were informed of the screening service by mail.

Screening Results

Three hundred thirteen residents participated in the screening, including 187 females and 126 males. Racial distribution of participants was 65.5% white, 29.7% black, and 4.8% who consider themselves a different race or ethnicity. Educational level of the participants varied as follows: 34.2% did not graduate from high school, 30.1% graduated from high school or received a General Equivalency Diploma, and 29.7% pursued education beyond high school. A description of the participants by annual income is as follows: 27% earned <$10,000, 21.4% earned $10,000-$19,000, 25.6% earned $20,000-$50,000, 10.2% earned >$50,000, and 15.3% refused to disclose income. Table 1 (shown on next page) displays a summary of the participants in regard to parish population.

Of the 313 people screened, 6 (1.9%) had elevated blood mercury levels of 20 ppb or more. In those with elevated levels, no relationship was observed regarding the species of fish consumed; although, each of these people consumed blue catfish, channel catfish, largemouth bass, or white crappie. Those with elevated levels were white commercial fishermen or family members of fishermen who resided in Morehouse or Ouachita parishes. Table 2 depicts the screening results for these six individuals.

In 48 (15.3%) of the participants, no blood mercury level was detected. The remainder of participants had normal levels in the range 0.5-19.9 ppb.

The data were analyzed in regard to age, occupation, race, education, frequency of fish consumption, and pregnancy.[29] Means and medians were calculated for each group and a sign test (P = 0.05) was performed to test for significant differences.

Five age categories were created-<7 years (n = 22), 7-19 years (n = 32), 20-39 years (n = 89), 40-59 years (n = 75), and >60 years (n = 93). Participants <7 years old had a significantly lower mean blood mercury concentration of 2.15 ppb as compared to all age groups as a whole. Those ages 7-19 had a significantly lower mean blood mercury concentration of 1.39 ppb as compared to all screening participants as a whole. The mean levels for the remaining age groups are as follows: age 20-39 = 2.63 ppb, age 40-59 = 4.45 ppb, and age >60 = 4.30 ppb. Although the levels for these three age groups were not found to be significantly different, there is a trend for blood mercury levels to increase with increasing age.

Occupation was related to higher blood mercury levels. Commercial fishermen and their household members (n = 18) had significantly higher levels than those in other occupations, with a mean of 6.65 ppb as compared to 3.21 ppb in all others tested (n = 295).

Mean blood mercury levels for black study participants (n = 93) was 2.43 ppb. This level is significantly lower than the mean of 3.84 ppb for the white participants (n = 205). Also, other racial/ethnic groups (n = 15) had significantly lower levels, mean of 3.67 ppb, as compared to whites.

In participants who did not graduate high school (n = 107), the mean blood mercury level is 3.67 ppb; high school graduates and GED holders (n = 93) had mean levels of 3.43 ppb; those with higher education (n = 97) had mean levels of 2.96 ppb. There is a trend for levels to decrease as education increases; however, none of the mean or median blood mercury levels were significantly different in regard to education.

Data regarding frequency of fish consumption was divided into three categories: at least once per week, once or twice a month, or less than six times a year. Those who ate fish at least once per week (n = 181) had a significantly higher blood mercury level, mean of 4.32 ppb, as compared to the other two groups. Those who ate fish once or twice a month (n = 85) had a mean level of 1.82 ppb and those who ate fish less than six times a year (n = 26) had a mean level of 2.08 ppb. All those with elevated blood mercury levels in this screening (n = 6) reported fish consumption of at least once a week.

The mean blood mercury level among pregnant women (n = 52) was 2.03 ppb. No elevated levels were detected in this group of participants. There was no statistically significant difference in levels among all female participants in regards to pregnancy status.

Table 1. Summary of Participants and Parishes Population Data

Parish	# of Participants		Parish Population*
	Male	Female	
Acadia	3	5	56,855
Bradley** (Arkansas)	1	0	Not Available
Caldwell	6	15	10,334
Evangeline	1	2	33,967
Jackson**	0	1	15,683
Jefferson Davis	1	3	31,830
La Salle**	1	1	13,795
Lafayette	1	5	176,592
Morehouse	22	70	32,062
Orleans	1	1	484,194
Ouachita	43	48	146,449
St. Landry	2	1	82,156
St. Martin	1	0	45,741
St. Tammany	19	16	167,242
Union**	1	4	21,475
Vermillion	1	0	50,794
Washington	22	15	42,899
Total	126	187	

*Wessex, Incorporated. 1994 Population Estimates
** These individuals presented at the clinic and were tested. Their parish / county of residence was not targeted in this screening.
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Table 2. Summary of Participants with Elevated Blood Mercury Levels

Gender	Parish of Residence	Level (PPB)
Male	Ouachita	19.6*
Male	Morehouse	20.6
Female	Ouachita	22.9
Male	Ouachita	26.7
Male	Morehouse	30.7
Male	Ouachita	35.1

Mean: 25.93 ppm Median: 24.8 ppm
*This level was included in the elevated range because of its close proximity to the cutoff value of 20 ppb
* These individuals presented at the clinic and were tested. Their parish / county of residence was not targeted in this screening.
Note: This table reproduced with permission from ATSDR, *Review of mercury health services' blood mercury data for selected parishes in Louisiana*, Atlanta: ATSDR; 1999.

DISCUSSION

Mercury occurs naturally in the environment and everyone is exposed to low levels of mercury through the air we breathe and the food and water we drink. Human activities, such as mining, combustion of fossil fuels, chloroalkali production, and mineral processing, increase the levels of mercury we are exposed to. The majority of mercury in the environment is inorganic or metallic mercury; exposure to this form of mercury is usually through inhalation, but also occurs through dietary and dermal pathways. Inorganic mercury vapors are released from metallic mercury spills, incinerators, and amalgam dental fillings.[30] Methyl mercury is an organic form of mercury created when microorganisms in the environment interact with inorganic mercury. Exposure to organic mercury is through inhalation, dermal, and dietary sources, as well. Consumption of fish living in contaminated waters is the primary source of nonoccupational exposure to methyl mercury for humans.

Analysis of the screening data provides new information regarding the risk of methyl mercury intoxication for Louisiana state residents. Most importantly, 98% of those screened had blood mercury levels in the normal range and none of those screened had levels in the toxic range. Therefore, ordinary consumption of local fish contaminated with methyl mercury, for most people, does not appear to pose a public health hazard at this time.

The six participants in the study with elevated blood mercury levels were all commercial fishermen or family members and lived in two of the thirteen parishes targeted – Ouachita and Morehouse parishes. This may be secondary to increased consumption of locally caught fish, as it is anecdotally known that fishermen eat more fish than non-fishing people do. Increased frequency of fish consumption is an established risk factor for elevated blood mercury levels.[31] None of these participants had levels high enough to require medical evaluation; however, it is important to continue educational efforts to all fishermen throughout the state regarding the risks of fish consumption in great quantities.

There are several possible explanations as to why participants with elevated levels were residents of only Ouachita and Morehouse parishes. Perhaps the fish from the bodies of water in these parishes have greater levels of methyl mercury contamination; thus, residents of these parishes who are more likely to consume locally caught fish would be more likely to have elevated blood mercury levels. It is also possible that increased numbers of volunteers from these two parishes have skewed the data-29% of participants were from Morehouse parish and 29% were from Ouachita parish. Further study is necessary to evaluate the true relationship between residing in these two parishes and risk for elevated blood mercury levels.

In this screening, blood mercury levels increased with increasing age. This is in agreement with other studies, which have considered age as a factor in methyl mercury exposure.[32] This may be due to increased fish consumption with increasing age. People 45 years and older have been shown to have higher fish consumption and mercury exposure than people in the 15-44 year age group.[33] Presumably, there is accumulation of methyl mercury within the body, which explains increasing levels with increasing age. Methyl mercury is excreted primarily through the biliary-hepatic cycle; this contributes to the long clearance half-life, estimated at approximately 50 days.[34] Individuals who consume fish on a frequent basis are accumulating methyl mercury in the body faster than it can be excreted.

In considering the results of this screening, we must point out some limiting factors. First, these results may or may not apply to the general public as a whole. Participants were self selected volunteers and not chosen by random methods. Also, the voluntary nature of the study limited the number of participants; future studies with a larger number of participants might suggest different conclusions. Finally recall error may be an issue in regards to the accuracy of the written questionnaires participants completed concerning risk factors for methyl mercury exposure.

Despite the limitations of applying this screening data to the general population, recommendations can be made regarding prevention of methyl mercury intoxication in Louisiana State residents. Primarily the state should continue annual testing of waterways for contamination with mercury and advisories regarding fish consumption should be updated accordingly. Also, educational efforts regarding the risk of methyl mercury exposure through increased consumption of locally caught fish should continue. These efforts should be directed towards members of high-risk groups, such as commercial and sports fishermen and their families. Fortunately none of those screened had blood mercury levels high enough to warrant medical evaluation. For this to remain true, the state must remain vigilant and continue annual monitoring of waterways for contamination in an attempt to prevent methyl mercury poisoning from the consumption of locally caught fish.

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