

Mercury Public Health Surveillance in Colorado: 2010 Annual Report

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Executive Summary

Mercury is a highly toxic and naturally occurring metal. Human exposure can occur in occupational settings, or from sources such as amalgams, pharmaceuticals, cosmetics, folk medicines, and household products. In the US, humans primarily accumulate mercury through the consumption of seafood. The Environmental Protection Agency (EPA) and the National Academy of Sciences (NAS) recommend keeping blood mercury levels less than 5µg/L, especially for pregnant women to decrease the risk of neurodevelopment effects.

Colorado requires clinical laboratories to report all cases of elevated levels of mercury in blood and urine. Active follow-up of mercury reports was initiated for the first time in Colorado in 2008. In 2010, a pilot project report was published based on the limited data set received during 2008-2009 that described mercury exposure in Colorado residents who have been reported to the Colorado Department of Public Health and Environment (CDPHE) because of elevated blood mercury levels. This is the first complete investigation which describes mercury exposure in Colorado residents based on all data reported to CDPHE because of elevated blood mercury levels from January to December, 2010. A survey was administered to a subset of those reported to further characterize those with elevated exposures and health risks. The mercury surveillance program of the Disease Control and Environmental Epidemiology Division (DCEED) of CDPHE also provides information to affected individuals and health care professionals with the objective of reducing the incidence of elevated levels of mercury among Colorado residents.

All blood mercury reports (n=667) received by the mercury surveillance program during a 1-year period were evaluated for exposures and health risks using the reference blood mercury level of 5.0µg/L recommended by the EPA and NAS. Two hundred and nine cases were at or above this reference blood mercury level (blood levels of 5.0 to 66.2µg/L). Overall, the age of these 209 cases ranged from 8-87 years. Of these 209 cases, 18% were women of child-bearing age and 67% were older than 46 years of age. In addition, 42% of cases had blood mercury levels that put them at risk of developing adverse nervous system effects, based on the Center for Disease Control and Prevention's (CDC) case definition for mercury poisoning of 10µg/L. It is important to note that only 2 cases (about 1%) were children between the ages of 6-12 years.

A survey on demographics, life style, fish consumption, and health concerns was sent to 198 cases with levels > 5µg/L for whom contact information was available. Among those who responded (29%), the results suggested that moderate to heavy consumption of fish that are commercially available in grocery stores and restaurants in Colorado resulted in moderate elevations in blood mercury. Health education through discussions and materials was provided to the 58 cases who returned the survey.

Our findings have some limitations. Given the public concern for methyl mercury in seafood, people who eat more fish may have been more likely to request testing, thus leading to testing bias. There was no chart review of the symptoms for each of the cases in the survey, and symptoms reported by the cases to their PCPs may have been

caused by other conditions. Selection bias may have been present since self-reported data is limited by a respondent's memory and ability to answer questions. The response rate for the survey was low, and these results cannot be generalized to the population. The 2010 surveillance period included only blood mercury results, thus limiting the ability to investigate exposures to inorganic and elemental mercury from sources such as dental amalgams. There was a noticeable homogeneity in the survey respondents in terms of education level attained and race (Appendix A, Table A1). Finally, four different laboratories analyzed the blood samples and this may introduce variability in sensitivity, accuracy, etc.

Overall, we conclude that excess consumption of commercially available fish from grocery stores and restaurants can result in elevated blood mercury levels in Colorado residents. This emphasizes a need to educate Colorado residents about how to choose fish to maximize health benefits, while minimizing health risks.

Introduction

Mercury is a highly toxic and naturally occurring metal. Human exposure can occur in occupational settings, or from sources such as amalgams, pharmaceuticals, cosmetics, folk medicines, and household products. All people have at least some amount of mercury in their body. Mercury enters the body via inhalation, ingestion and absorption through the skin. The Centers for Disease Control and Prevention (CDC) reports that the geometric mean blood mercury concentration in the U.S. population age 20 years and older is 0.833-1.07 µg/L (CDC, 2009a). In the United States, humans are exposed to mercury mostly through fish consumption and certain occupations (CDC, 1996). Significant controversy surrounds mercury in dental amalgams and the current scientific evidence does not support a causal association between this and various systemic symptoms (CDC, 2009b; Woods et al 2007).

In nature, mercury exists in three forms: elemental, organic and inorganic salts. All forms are poisonous to humans and can produce a wide range of health effects depending on the amount and duration of exposure. High levels of any form of mercury can permanently damage the brain, kidneys and a developing fetus. Yet, there are major differences in the biological response to inorganic and organic mercury, as well as its route of exposure (Material Safety Data Sheet, 2008; ATSDR, 2006).

Metal mercury vapors and methyl mercury are most harmful because both can access the brain. Mercury accumulates in the body and causes delayed neurological effects. The neuro-developmental effects are most sensitive and well-documented in humans. Other health impacts include cardiovascular disease, immune deficiency and reproductive complications. Early clinical symptoms include paresthesia (tingling and numbness in the toes, fingers, mouth and lips), ataxia (lack of coordination of muscle movement), generalized weakness, vision and auditory difficulties, muscle spasms and tremors (Olsen, 2009).

Another important aspect to elevated blood mercury levels are its effect on children. The US Environmental Protection Agency (EPA) has determined that children born to women with a blood mercury concentration of 5.8µg/L or higher are at increased risk of adverse health effects. In addition, both the EPA and the National Academy of Sciences (NAS) have determined that 32µg/L of mercury in the blood of pregnant women doubles the risk of the child having and abnormal performance on a range of neurodevelopmental tests (EPA, 2001). Both recommend keeping the blood mercury level <5µg/L (NAS, 2000; EPA IRIS, 2001) for pregnant women. This blood mercury level corresponds to the EPA reference dose (RfD) for methylmercury of 0.1µg/kg body weight/day, below which exposures are likely to be without appreciable adverse health effects, even for sensitive individuals. This reference dose gives guidance to public health and regulatory programs seeking to reduce mercury exposures and adverse health effects.

Nationally, professional groups and federal programs maintain their own guidelines. The CDC only considers blood or urine mercury levels above 10µg/L as significant (Belson et al., 2005). The American Conference of Governmental Industrial Hygienists

(ACGIH) uses a Biological Exposure Index which sets the occupational exposure limit for serum inorganic mercury toxicity at 15µg/L. The Agency for Toxic Substances and Disease Registry (ATSDR, 2006) recommends the neurotoxicity threshold for methyl mercury to be 50µg/L in the blood for self-reported nonspecific complaints (malaise, weakness, decreased cognition) and 200µg/L in the blood for physical exam findings (paresthesia, ataxia, visual difficulties and worsening hearing).

The State of Colorado “Regulations Pertaining to the Detection, Monitoring, and Investigation of Environmental and Chronic Diseases (6 CCR 1009-7)” require that within 30 days of the test all clinical laboratories in the state report any blood and urine tests where mercury levels exceed 5µg/L for blood and 20µg/L for urine. This is intended for the protection of the developing fetus based on the available toxicological health information. Colorado’s mercury surveillance system is built on the above-mentioned reporting requirement that includes the collection of sufficient information about tested individuals. The system further depends on follow-up conducted by the program staff or health care providers to identify the source of exposure.

Purpose

Overall, the purpose of mercury surveillance in Colorado is to improve the tracking, prevention, and mitigation of human health impacts of environmental and occupational exposures to mercury. This investigation describes mercury exposure in Colorado residents, who have been reported to the Colorado Department of Public Health and Environment (CDPHE) because of elevated mercury levels, and survey results (e.g., demographic, life style) that can be used to further characterize those with elevated exposures and health risks. Furthermore, we evaluate the efficacy of the current surveillance and investigation mechanisms in reducing elevated mercury levels among Colorado residents. The data are also used, when possible, to conduct interventions to reduce exposures and potential adverse health effects to the individuals with the elevated mercury levels.

Methods

Participating Laboratories and Reporting Mechanism

Analytical laboratories in Colorado are required to submit elevated blood and urine mercury data. Major reporting laboratories include Quest Diagnostics, Lab Corp, and Specialty Labs.

The labs currently report their data via an electronic system. Reports are submitted to CDPHE at a minimum of once per week. Variables reported include personal identifiers (name, gender, age, and birthdate), ordering health care provider contact information, and clinical information (date of test, date of report, clinical test used, and test result). Most reports lack demographic information, such as residential address, race or ethnicity. The health care provider listed on the laboratory report was contacted by telephone and asked to provide patient contact information.

Prioritization of Survey Eligible Cases: Action Thresholds

Although the CDPHE reportable level is $>5\mu\text{g/L}$ for blood, laboratories report all blood mercury tests performed within their facility regardless of residency status. The follow-up survey and exposure investigations focused on all individuals residing in Colorado with blood mercury test result $>5\mu\text{g/L}$; however, cases with a level of $5\mu\text{g/L}$ were sent a survey if they were females of childbearing age.

Patients from which an address was successfully obtained were sent an introductory letter and follow-up survey (Appendix B). Patients chose either to complete the questions on the paper form and return it to the mercury surveillance program of DCEED, or to complete the follow-up survey by phone with a staff member.

Categorization of Survey Eligible Cases

All reports above $>5\mu\text{g/L}$ received by the mercury surveillance program of DCEED were categorized in to three blood groups using selected cut points:

- 5.0 to $9.9\mu\text{g/L}$ (referred to as 5-9): Where the lower-end is based on the EPA's RfD of $0.1\mu\text{g/kg/day}$ which corresponds to $<5\mu\text{g/L}$ of methylmercury in blood, and the upper-end is below the CDC's case definition for chemical poisoning, which is blood mercury levels exceeding $10\mu\text{g/L}$.
- 10.0 to $14.9\mu\text{g/L}$ (referred to as 10-14): Where the lower-end is based on CDC definition of poisoning exceeding $10\mu\text{g/L}$ and the higher-end is based on the ACGIH Biological Exposure Index (BEI) for blood mercury of $15\mu\text{g/L}$ for occupational exposure to inorganic mercury.
- $>15.0\mu\text{g/L}$ (referred to as 15+): Blood levels above occupational BEI of $15\mu\text{g/L}$.

For individuals with more than one test, the first test result was used for mercury group level classification.

Survey

Information collected during the survey included potential environmental or occupational exposures to mercury, and health effects experienced by reportable cases. Seafood consumption was classified as the number of meals per week. After completing the survey, general information was provided to the patient about limiting potential mercury contacts. Exposures were also evaluated to determine if additional public health or occupational health and safety measures were warranted to prevent or reduce susceptibility to others facing similar conditions.

All information obtained from laboratory reports and surveys was used for public health surveillance and prevention purposes only. The data was maintained in compliance with CDPHE policies for the privacy and security of confidential and protected health information.

Results

Summary for All Reported Tests

Between January 1st and December 31st, 2010, the mercury surveillance project received 667 laboratory reports of blood mercury tests. The data reported for 2010 consisted entirely of blood mercury as no reportable urine mercury cases were received during this period. Of the reports received, blood mercury levels ranged from 1.0 to 66.2µg/L with a geometric mean blood mercury level of 2.94µg/L (Table 1).

Table 1. Summary of All Mercury Test Results

Group	Range	Mean	*Geometric Mean	Median	<i>n</i>
All Cases	1 – 66.2	5.22	2.94	2	667
Males	1 – 55	5.57	3.00	2	362(54%)
Females	1-66.2	4.81	2.88	2	305(46%)

*Geometric mean was calculated with all tests among individuals above 19 years

Table 2 shows the mercury surveillance program received laboratory reports on 402/611 (65%) individuals with blood mercury levels below 5.0µg/L, which was below the reporting requirement, and 209 individuals with blood mercury levels at or above the CDPHE reportable level of 5.0µg/L. Twenty percent (121/611) were from 5-9µg/L, 8% (47/611) were from 10-14µg/L, and 7% (41/611) were greater than 15µg/L.

Of the 41 reported cases with blood mercury levels greater than 15µg/L, 1 was between 30-50µg/L and 2 (9%) were greater than 50µg/L. Fourteen percent (88/611) of the blood mercury tests exceeded CDC's case definition for mercury poisoning (i.e. a level above 10µg/L), and 41/611 (7%) exceeded ACGIH's BEI for occupational exposure. No females of child-bearing age exceeded the 32µg/L EPA threshold of pregnant women for increased risk of neurodevelopmental effects on the fetus.

Table 2. Total Number of Cases Received During the 2010 Surveillance Period

Blood Mercury Level (PPB; □ µg/L)	# Reports	Gender		Age		
		Female	Male	< 19	19-45	46+
< 5.0	402/611 (65%)	183/402 (46%)	219/402 (54%)	41/402 (10%)	129/402 (32%)	232/402 (58%)
5-9	121/611 (20%)	63/121 (52%)	58/121 (48%)	1/121 (1%)	41/121 (34%)	79/121 (65%)
10-14	47/611 (8%)	25/47 (53%)	22/47 (47%)	1/47 (2%)	16/47 (34%)	30/47 (64%)
15+	41/611 (7%)	16/41 (39%)	25/41 (61%)	0/41 (0%)	9/41 (22%)	32/41 (78%)
Total	611	287/611 (47%)	324/611 (53%)	43/611 (7%)	195/611 (32%)	373/611 (61%)

NOTE: For individuals/cases with multiple blood tests, the maximum blood mercury level was retained for analysis.

Seven percent (43/611) of all reported tests were from people under the age of 19. Two of these individuals had levels above or at 5.0µg/L and belonged to the age group 6 to 12 years. Fourteen percent of reported tests were from women of child-bearing age (data not shown).

Characteristics of Survey Eligible Cases by Age and Gender

Two hundred and nine reported tests met the eligibility criteria of above 5µg/L. As shown in Table 3, the results were split evenly between men (50%; 105/209) and women (50%; 104/209). Blood mercury levels in males ranged from 5-55µg/L with a geometric mean of 10.09µg/L, and in females it spanned from 5-62µg/L with a geometric mean of 8.89µg/L. For 209 survey eligible cases, the age range was 8-87 years old, with the majority older than 46 years of age (67%, 141/209) and the remaining cases (33%, 68/209) between 8-45 years old (data not shown). Nineteen percent (39/209) of cases were women of child-bearing age (Table 4). The majority of the cases had blood mercury levels between 5-9µg/L.

Table 3. Summary of All Eligible Cases

Group	Range	Mean	*Geometric Mean	Median	<i>n</i>
All Cases	5 – 66.2	10.96	9.48	9.0	209
Males	5 – 55.0	11.74	10.09	9.3	104(50%)
Females	5-66.2	10.17	8.89	8.0	105(50%)

NOTE: Geometric mean was calculated for all individuals/cases above 19 years. When an individual had multiple blood tests, the maximum blood mercury level was retained for analysis.

Table 4. Summary of Survey Eligible Cases by Gender and Age

Blood Mercury Level (PPB; □µg/l)	# Reports	Gender		Age			Women of Child-bearing Age
		Female	Male	<19	19-45	46+	
5-9	121/209 (58%)	63/121 (52%)	58/121 (48%)	1/121 (1%)	41/121 (34%)	79/121 (65%)	25/63 (40%)
10-14	47/209 (22%)	25/47 (53%)	22/47 (47%)	1/47 (2%)	16/47 (34%)	30/47 (64%)	21/25 (84%)
15+	41/209 (20%)	16/41 (39%)	25/41 (61%)	0/41 (0%)	9/41 (22%)	32/41 (78%)	3/16 (19%)

Total	209	104/209 (50%)	105/209 (50%)	2/209 (<1%)	66/209 (32%)	141/209 (67%)	39/209 (19%)
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^a For individuals/cases with multiple blood tests, the maximum blood mercury level was retained for analysis.

Characteristics of Patients tested by Geography

As shown below in Table 5, the majority of reported tests (48%, 240/502) were received from individuals in the six county Denver metro areas. This distribution is expected since 54% of the overall Colorado state population is concentrated in the same area. Reported tests outside of the metro area were randomly distributed throughout the rest of the state (33 out the 64 counties of Colorado) as shown in Appendix A, Figure A1. Pitkin County has the highest rate in the state followed by Cheyenne, Pueblo and Boulder. Boulder has the highest number of reported tests (22%, 109/502). It is, important to note that the calculated rate from each county should be interpreted with caution because of small numbers.

Table 5. Distribution of reported Mercury Tests by County

County	# Reports	Rate per 100,000
Adams	6	1.36
Arapahoe	33	5.77
Bent	1	15.39
Boulder	109	37.00
Chaffee	1	*
Cheyenne	1	*
Clear Creek	1	*
Crowley	1	*
Delta	4	12.92
Denver	41	6.83
Douglas	25	8.76
Eagle	6	11.49
El Paso	28	4.50
Fremont	12	25.63
Garfield	7	12.41
Jefferson	26	4.86
Kit Carson	1	*
La Plata	2	*
Larimer	39	13.02
Las Animas	2	*
Logan	3	*
Mesa	10	6.82
Moffat	1	*
Montrose	2	*
Morgan	2	*
Pitkin	20	116.63
Prowers	1	*
Pueblo	72	45.27
Routt	4	17.01
San Miguel	2	*
Summit	1	*
Teller	6	4.28

Weld	37	14.63
Total	502	

NOTES:

- Bold values represent Denver metro area
- Rate per 100,000 = # of individuals for a particular county (e.g., 24 for Denver) divided by the population of that county x 100,000
- * Rates were not calculated when reports were received for < 4 individuals
- Of the 611 individuals tested, only 502 had residential addresses listed

Summary of Survey Results

Response rate

Surveys were sent to 198 individuals who were Colorado residents and for whom contact information was obtained. Fifty eight surveys were completed and returned for a response rate of 29%. The highest response was among those with blood mercury levels above 15µg/L (Table 6).

Table 6. Summary of all reported cases for the 2010 surveillance period

Blood Mercury Level (PPB, □µg/L)	# Reports	Survey eligible reports	Completed Surveys	Response Rate
5-9	121	112	32	28%
10-14	47	45 ^a	10	22%
15+	41	41	16	38%
Total	209	198	58	29%

^a Addresses were not available for 2 cases

Blood mercury Levels of Surveyed Cases

Blood mercury levels for the 58 cases ranged from 5.0 to 25µg/L. As shown in Table 6, 32 were completed for the 5-9µg/L blood mercury group, 10 for the 10-14µg/L group, and 16 for the 15+µg/L group. Of the 32 surveys for the 5-9µg/L group, 5 (16%) were completed by women of child-bearing age. In relation to the 58 completed surveys, 17% (10/58) exceeded CDC's Case Definition for chemical poisoning of 10µg/L, and 28% (16/58) were above the ACGIH's BEI of 15µg/L for occupational exposure to inorganic mercury.

Demographics

Everyone that completed and returned a survey reported having college, graduate, or professional level education (Appendix A, Table A1). Equal numbers of males (29/58) and females (29/58) completed the survey. However, in the 15+µg/L group, 60% (9/15) of the respondents were women. All were White, Non-Hispanic with the exception of one African-American. Only 3 individuals reported having children under the age of 7 years that lived with them or visited frequently (Appendix A, Table A5.1). None of the survey respondents noted they were pregnant, nursing, or had a child living with them who had come into contact with any mercury-related spills (Appendix A, Table A5.3).

Reasons for Blood Mercury Testing

As shown in Appendix A, Table A3, a large majority of survey respondents (46/58; 79%) reported that their PCP had informed them of their blood mercury results. Eighty three percent of respondents (48/58) reported knowing why their PCP had ordered the blood mercury analysis. The main reasons included symptoms such as peripheral neuropathy as well as patient request due to high fish consumption.

Less than a quarter of the respondents (12/58; 21%) had been tested for blood mercury in the last five years. Seventy two percent (39/58) did not intend on having a blood mercury test in the future, including 60% (6/10) in the 10-14 blood group and 44% (7/16) in the 15+µg/L group (Appendix A, Table A3).

Potential Sources of Mercury Exposure

Most of the respondents reported fish consumption and dental amalgam as their potential primary source of mercury exposure. One respondent was reported by his provider to have been occupationally exposed to mercury. All 58 survey respondents reported eating fish and a majority (74%) reported having at least one amalgam filling. Thus, most respondents probably had multiple potential exposure sources to mercury. This investigation, however, had a limited ability to determine the contribution of mercury from sources other than the fish consumption because urinary mercury levels, which are needed to detect inorganic mercury, were not ordered by the PCPs. Furthermore, since everyone reported some fish consumption, comparisons to non-fish eaters are not feasible. Nonetheless, it is reasonable to rely on the available data that indicates moderate to high fish consumption (i.e. consuming fish more than once a week) as a potential major source of exposure. A summary of potential sources in this group is provided in Appendix A, Table A9.1.

Table 7. Summary of Fish Consumption

	Reportable Blood Mercury Level (PPB, □□ g/l)	Daily	Few times / week	About once / week	Less than once / week	About once / month	Less than once / month	Never	Don't know / not answered
How often do you eat fish or seafood?	5-9	3/32 (9%)	21/32 (66%)	6/32 (19%)	1/32 (3%)	1/32 (3%)	0	0	0
	10-14	1/10 (10%)	5/10 (50%)	3/10 (30%)	1/10 (10%)	0	0	0	0
	15+	3/16 (19%)	9/16 (56%)	4/16 (25%)	0	0	0	0	0
	Total	7/58 (12%)	35/58 (60%)	13/58 (22%)	2/58 (4%)	1/58 (2%)	0	0	0

1) Fish Consumption

As shown in Appendix A, Table A7, fish consumption more than once a month was reported by all survey respondents. Four percent of the respondents (2/58) reported

that they ate fish less than once a week, 22% (13/58) reported once per week consumption, 60% (35/58) reported eating it a few times per week and 12% (7/58) reported daily intake. Prior to the initial blood mercury analysis, 69% (40/58) reported no change in the frequency of their fish consumption, while 21% (12/58) were eating more, and the remaining 10% (6/58) had been consuming less (Table A7.2). Most people bought fish at the grocery store or ate it in a restaurant (Appendix A, Table A7.4). Only two people reported eating fish they had caught locally. Those who purchased fish at the grocery store typically bought it fresh or frozen, with the exception of canned tuna.

2) Dental Amalgams

Overall, a large number of survey respondents (59%; 34/58) reported having dental amalgam fillings, which contain approximately 50% of mercury by weight. In the 5-9µg/L, 10-14 µg/L, and 15µg/L blood groups, the number of people with dental amalgams was 62% (20/32), 60% (6/10), and 50% (8/16) respectively (Appendix A, Table A4). The relationship between the number of tooth amalgams and blood mercury levels is unknown because the contribution of tooth amalgam to mercury levels in the body can only be evaluated through urine mercury levels.

3) Occupational

As shown in Appendix A, Table A8.1, six people worked in the healthcare industry in locations such as doctor's offices, hospitals, and/or surgery centers. The level of mercury exposure, if any, in these occupational settings is not known. Two of these individuals (a neurosurgeon and a laboratory technician) belonged to the 15+ mercury level group but their responses to the survey indicated fish consumption as the likely source of mercury exposure. No individuals reported working in a mine or any occupational settings in which mercury exposure has been well established (Appendix A, Table A9.1). However, one individual who had a close relative working in a mine.

Religious Practices, Folk Medicine/Herbal Remedies, Antiques, and Outdated Medication

As shown in Appendix A, Tables A9 and A9.1, 22% (13/58) of survey respondents noted that they could be exposed through one or more of the following potential sources; folk medicine, herbal remedies, photography development and fluorescent light bulbs. Four of these thirteen individuals (31%) used folk medicine and/or herbal remedies and had a blood mercury level between 5- 15 µg/L. The amount of mercury in these products is not known. The majority of these persons also reported a high frequency of fish consumption.

Symptoms Reported

As shown in Appendix A, Tables A6 and A6.1, 47% of survey respondents (27/58) reported that their PCP had identified symptoms that could be related to mercury exposure during the initial office visit. The most common symptoms included numbness and tingling, insomnia, weakness, headache, and short term memory loss.

Statistical Analysis of Mercury Blood Level and Symptoms

To further examine the association between the symptoms and blood mercury levels, the Fisher’s Exact Test was performed on the responses to Question 7: signs and symptoms identified during the original doctor’s visit (Table 8). For this analysis, the blood mercury levels of all survey respondents with values above 5µg/L were categorized as either “low” (> 5µg/L but < 12µg/L) or “high” (>= 12µg/L). Ten of the sixteen possible symptoms that were answer options to this question were reported and are listed. The odds ratio (OR) for each symptom was calculated for the “high” to “low” subgroups.

As Table 8 shows, only metallic taste had an OR greater than 1.0, but like all of the other symptoms, the confidence intervals were wide, included “1.0” and had a p-value greater than 0.05. Thus, there are no statistically significant associations between blood mercury level and the symptoms reported by the survey respondents.

Table 8. Association Tests (Finite Population) to Responses for Question 7:

Condition	Odds Ratio	95% Confidence Interval	p-value
Headache	0.4474	(0.0487, 4.1102)	0.4789
Incoordination	0.9445	(0.1631, 5.4675)	0.9503
Insomnia	0.5926	(0.1117, 3.1417)	0.5458
Irritability	0.4474	(0.0487, 4.1102)	0.4789
Leg Cramps	0.4342	(0.04717, 3.9968)	0.4623
Malaise	0.614	(0.0625, 6.035)	0.6808
Metallic Taste	1.9474	(0.1219, 31.1526)	0.6402
Numbness/Tingling	0.6136	(0.1714, 2.1968)	0.4625
Short Term Memory Loss	0.3474	(0.0394, 3.0628)	0.3363
Weakness	0.3474	(0.0394, 3.0628)	0.3363

Note: p-value (0.05) is computed using the Fisher’s Exact Test.

Summary of Findings for Multiple Tests

Thirty five individuals had their blood mercury levels tested more than once during the survey period, and ten out of 35 returned the survey. The change in mercury level for each retested individual was measured by calculating the difference in blood level between the first and last tests within the one-year surveillance period. This difference was then averaged for all retested individuals by their mercury level group. The overall average difference in blood mercury cases across all blood mercury groups was 2.95µg/L. In the 5-9 µg/L mercury level group, there was an average increase of 9.33 µg/L. However, a decrease was noticeable (8.33 µg/L) in the 15+ µg/L blood mercury group.

When comparing individuals with returned survey (10 patients with multiple tests) to the remaining individuals with more than one mercury test, the same pattern existed in the 15+ µg/L blood mercury group and a decrease instead of an increase was noticed in the 5-9 µg/L group. These findings indicate that significant changes in blood mercury levels are achievable over a relatively short period of time ranging from 1 to 4 months. (Appendix A, Table A2).

Summary of Intervention Results

The healthcare providers of the ten patients with repeat mercury results who completed the survey were contacted for this study. Six of the 10 were reported to have had a high consumption of seafood, particularly tuna and sushi, in the months prior to the first elevated mercury level. Over the course of a year, the providers reported educating their patients on lowering consumption of high risk fish which on follow-up is believed to have caused a decline in blood mercury by an average of 6.5 µg/L. The physicians for the remaining four individuals reported that those patients never returned for repeat testing. In addition, one clinician who was caring for a child with an elevated serum mercury level contacted the authors to report a decrease due to a reduction in sea food consumption; however, a survey was not completed for this child.

Discussion

This investigation identified moderately elevated mercury levels through public health surveillance that may be due to moderate to heavy consumption of commercially available fish in grocery stores and restaurants in Colorado. This finding is in agreement with previous studies on the consumption of commercially available fish and elevated blood mercury levels (Hightower and Moore, 2003; Kale and Goodman, 2002). It should be noted that the sample size in this investigation was not sufficiently large to provide a clear picture of the extent of exposure or the consumption characteristics of consumers. Only two cases (2/209) were under the age of 19 years. Fish consumption could not be investigated in relation to demographic factors because there was little variation in the race/ethnicity and educational level of respondents. In fact, almost all respondents were white and had at least a college degree. In addition, the highest percentage of reportable cases were received for ≥46 year old age group. The data did not demonstrate specific pattern of blood mercury concentrations related to other potential sources of exposure such as dental amalgams or occupational exposures. This investigation could not determine the contribution of mercury from sources other than fish consumption because urinary mercury levels were not obtained. Furthermore, all persons completing the survey reported some fish consumption, so there could be no comparison to non-fish eaters.

This investigation had a limited ability to determine whether mercury is causing or exacerbating the symptoms that were self-reported. No specific pattern of symptoms related to blood mercury levels was observed. It is important to note that 42% of cases (88/209) had blood mercury levels above 10µg/L, a range of possible concern for developing adverse nervous system effects based on CDC's Case Definition of chemical poisoning (Belson et al., 2005). Almost one percent of cases (2/209) had blood mercury levels at or above the neurotoxicity threshold of 50µg/L that is suggested by the ATSDR (ATSDR, 2006). Fourteen percent women of child-bearing age had levels exceeding what is considered unsafe by the EPA and NAS (i.e. 5 µg/L); however, no one had blood mercury readings above 32µg/L, which is the level that doubles the risk of fetal abnormalities.

Our findings have some limitations:

- Given the attention to methyl mercury in seafood, people who eat more fish are likely to request more testing. This may lead to testing bias. The true population prevalence of elevated mercury levels are unknown in Colorado.
- To date, quality assurance has not been performed to determine the completeness of blood lead level reporting from all laboratories in Colorado.
- A chart review of symptoms reported by cases in the survey was not done. In addition, many symptoms reported by cases to their PCPs can be caused by other conditions (e.g., diseases and chemicals).
- Selection bias may be present since self-reported data is limited by a respondent's memory and ability to answer questions.
- The response rate for the survey was low, and these results cannot be generalized to the population.
- The 2010 surveillance period included only blood mercury results. This limits the ability to investigate exposures to inorganic and elemental mercury from sources such as dental amalgams.
- There was a noticeable homogeneity in the survey respondents in terms of education level attained and race (Appendix A, Table A1)
- Four different laboratories analyzed the blood samples and this may introduce variability in sensitivity, accuracy, etc.

In conclusion, the consumption of commercially available fish from grocery stores and restaurants can result in elevated blood mercury levels. Changes in fish consumption habits may be effective in reducing potentially harmful blood mercury levels. This indicates the need to educate Colorado residents about how to properly select fish to maximize health benefits, while minimizing health risks.

In the future, the mercury surveillance program will explore ways to best reach consumers by working with other CDPHE programs that are also concerned with dietary interventions. Due to the low response rate over a 1-year period, efforts will be made to increase participation by considering other secure means of communications, such as e-mail.

There are no national guidelines for medical providers to use to determine if a mercury test is warranted. Standard guidelines for clinicians would be helpful in guiding mercury testing for the general population or specific subpopulations.

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Appendix – A: Summary Tables and Figures

Table A1. Completed surveys: age, gender, and education during 2010 surveillance period

Reportable Blood Mercury Level (PPB, $\mu\text{g/L}$)	# Completed surveys (% of N=58)	Gender	Education level attained
5-9	32/58 (55%)	F= 17/32 (53%) M = 15/32 (47%)	college, graduate, or professional level education
10-14	10 /58 (17%)	F = 3 /10 (30%) M = 7/10 (70%)	college, graduate, or professional level education
15+	16/58 (28%)	F=9/16 (56%) M= 7/16 (44%)	college, graduate, or professional level education
Total	58/58	F = 29 /58 (50%) M = 29/58 (50%)	

Note: All cases were nonhispanic white, except one was African-American

Table A2. Reportable cases: patients tested more than once in 2010 surveillance period

	Initial Reportable Blood Mercury Level (PPB, µg/L)	Number of persons retested	Average Decrease in Blood Mercury Level (PPB, µg/L)
Patients tested more than once over 1-year surveillance period	<5	3	+0.25
	5-9	12	+0.27
	10-14	9	2.68
	15+	11	8.33
	Total	35	2.95
Patients retested that filled surveys	5-9	3	+9.33
	10-14	4	-2.02
	15+	3	-8.5
	Total	10	- 2.43
Case details	<p style="text-align: center;"><u>5-9</u></p> <p>Case 1: tested 2 times in 4 months and 10 days, mercury level increased from 9 to 13 (+4) PPB Case 2: tested 2 times in 4 months and 3 days, mercury level increased from 5 to 22 (+17) PPB Case 3: tested 2 times in 7 month and 20 days, mercury level increased from 6 to 13 (+7) PPB <u>4+ 17+ 7 = 28/3 = +9.33</u></p> <p style="text-align: center;"><u>10-14</u></p> <p>Case 4: tested 2 times in 2 months and 7 days, mercury level dropped from 11 to 7 (-4) PPB Case 5: tested 3 times in 7 months and 16 days, mercury level dropped from 10.5 to 4 (-3.7) PPB Case 6: tested 2 times in 4 months and 5 days, mercury level dropped from 11.4 to 5.8 (-5.6) PPB Case 7: tested 2 times in 1 month and 2 days, mercury level increased from 10.4 to 15.6 (+5.2) PPB $\{(-4)+(-3.7)+(-5.6)\} - (+5.2)/4 = 13.3-5.2 = 8.1/4 = -2.02$</p> <p style="text-align: center;"><u>15+</u></p> <p>Case 8: tested 2 times in 3 month and 3 days, mercury level dropped from 21.10 to 10.10 (-11) PPB Case 9: tested 2 times in 9 months and 3 days, mercury level dropped from 17.9 to 8.6 (-9.3) PPB Case 10: tested 2 times in 1 month and 5 days, mercury level dropped from 18.3 to 13.10 (-5.2) PPB $(-11)+ (-9.3)+ (-5.2) = 25.5/3 = -8.5$</p> <p>Group Average: $\{(-8.1)+ (-25.5)\} - (+9.33) = -24.27/10 = -2.43$</p> <p>Note: The provider of a child with elevated blood mercury level reported a drop in the blood mercury level (from to 1.6 µg/L) following a reduction in sea food consumption.</p>		

Table A3. Questions regarding reasons for requesting mercury blood test

Question	Reportable Blood Mercury Level (PPB, $\mu\text{g/L}$)	Yes	No	Don't know/ not answered
Were you ever notified of the result of the blood/urine test for mercury?	5-9	21/32 (66%)	9/32 (28%)	2/32 (6%)
	10-14	9/10 (90%)	1/10 (10%)	0/10
	15+	16/16 (100%)	0/16	0/16
	Total	46/58 (79%)	10/58 (17%)	2/58 (3%)
Do you know why your doctor tested for mercury?	5-9	23/32 (72%)	9/32 (28%)	0/32
	10-14	10/10 (100%)	0/10	0/10
	15+	15/16 (94%)	1/16 (6%)	0/16
	total	48/58 (83%)	10/58 (17%)	0/58
Do you know how you were exposed to mercury?	5-9	7/32 (22%)	23/32 (72%)	2/32 (6%)
	10-14	5/10 (50%)	4/10 (40%)	1/10 (10%)
	15+	8/16 (50%)	6/16 (38%)	2/16 (12%)
	total	20/58 (34%)	33/58 (57%)	5/58 (9%)
Have you had any previous mercury testing in the last 5 years?	5-9	3/32 (9%)	24/32 (75%)	5/32 (16%)
	10-14	3/10 (30%)	7/10 (70%)	0/10
	15+	6/16 (38%)	8/16 (50%)	2/16 (12%)
	total	12/58 (21%)	39/58 (67%)	7/58 (12%)
Do you have another mercury test scheduled?	5-9	1/32 (3%)	29/32 (91%)	2/32 (6%)
	10-14	4/10 (40%)	6/10 (60%)	0/10
	15+	7/16 (44%)	7/16 (44%)	2/16 (12%)
	total	12/58 (21%)	42/58 (72%)	4/58 (7%)

Table A4. Questions regarding silver amalgam fillings

Question	Reportable Blood Mercury Level (PPB, µg/L)	Yes	No	Don't know/ not answered
Do you have any silver amalgam dental fillings?	5-9	20 (62%)	6 (19%)	6(19%)
	10-14	6 (60%)	4(40%)	0
	15+	8 (50%)	7(44%)	1(6%)
	Total	34 (59%)	17(29%)	7(12%)
If you have silver amalgam fillings: have any of your fillings broken in the last 6 months?	5-9	5(16%)	20(62%)	7(22%)
	10-14	1(10%)	8(80%)	1(10%)
	15+	2 (13%)	6(37%)	8(50%)
	Total	8(14%)	34(59%)	16(28%)

Table A5: Questions regarding children

Question	Reportable Blood Mercury Level (PPB, µg/L)	Yes	No	Don't know/ not answered
Do you have any children younger than 7 who either live with you, or who frequently visit you?	5-9	5/32 (16%)	27/32 (84%)	0
	10-14	2/10 (20%)	8/10 (80%)	0
	15+	3/16 (19%)	13/16 (81%)	0
	Total	10/58 (17%)	48/58 (83%)	0

Table A5.1 Questions regarding children: exposure to mercury spills

Question	Reportable Blood Mercury Level (PPB, µg/L)	Yes	No	Don't know/ not answered
If you have any children younger than 7 who either live with you, or who frequently visit you, have these children ever been tested for mercury?	5-9	1/32 (3%)	11/32 (34%)	20/32 (63%)
	10-14	0/10	2/10 (20%)	8/10 (80%)
	15+	0/16	7/16 (44%)	9/16 (56%)
	Total	1/58 (2%)	20/58 (34%)	37/58 (64%)

Table A5.2. Questions regarding children: mercury tests

Question	Reportable Blood Mercury Level (PPB, $\mu\text{g/L}$)	Yes	No	Don't know/ not answered
If you have any children younger than 7 who either live with you, or who frequently visit you, have these children ever been tested for mercury?	5-9	1/32 (3%)	11/32 (34%)	20/32 (63%)
	10-14	0/10	2/10 (20%)	8/10 (80%)
	15+	0/16	7/16 (44%)	9/16 (56%)
	Total	1/58 (2%)	20/58 (34%)	37/58 (64%)

Table A5.3. Questions regarding children: exposed in-utero or via breastfeeding

Question	Reportable Blood Mercury Level (PPB, $\mu\text{g/L}$)	Yes	No	Don't know/ not answered
Is anyone in the house pregnant or nursing?	5-9	0/32	32/32 (100%)	0/32
	10-14	0/10	10/10 (100%)	0/10
	15+	0/16	16/16 (100%)	0/16
	Total	0/10	58/58 (100%)	0/8

Table A6. Questions regarding symptoms

	Reportable Blood Mercury Level (PPB, $\mu\text{g/L}$)	Yes	No	Don't know/ not answered
During your original visit, did your doctor identify any of the following signs or symptoms?	5-9	16/32 (50%)	14/32 (44%)	2/32 (6%)
	10-14	4/10 (40%)	6/10 (60%)	0/10
	15+	7/16 (44%)	4/16 (25%)	5/16 (31%)
	Total	27/58 (47%)	24/58 (41%)	7/58 (12%)

Table A6.1. Specific Symptoms listed

Listed Symptom, MORE THAN ONE SELECTION OK					
Reportable Blood Mercury Level (PPB)	Headache	Poor Coordination	Weakness	Malaise	Blurred vision
Total	5	5	6	4	2
5-9	1/5 (20%)	2/5 (40%)	2/6 (33%)	2/4 (50%)	0/2 (0%)
10-14	2/5 (40%)	1/5 (20%)	3/6 (50%)	1/4 (25%)	1/2 (50%)
15+	2/5 (40%)	2/5 (40%)	1/6 (17%)	1/4 (25%)	1/2 (50%)
Reportable Blood Mercury Level (PPB)	Depression	Numbness / tingling	Impaired hearing	Short-term memory loss	Impaired sense of smell
Total	3	14	4	5	2
5-9	2/3 (67%)	9/14 (64%)	2/4 (50%)	4/5 (80%)	2/2 (100%)
10-14	1/3 (33%)	2/14 (14%)	2/4 (50%)	0/5	0/2
15+	0/3	3/14 (22%)	0/4	1/5 (20%)	0/2
Reportable Blood Mercury Level (PPB)	Leg Cramps	Insomnia	Irritability	Loss of Appetite	Other
Total	4	8	4	3	
5-9	3/4 (75%)	6/8 (75%)	2/4 (50%)	3/3 (100%)	Fatigue, hair loss Arthritis, Tremor, Metallic taste
10-14	0/4	0/8	1/4 (25%)	0/3	
15+	1/4 (25%)	2/8 (25%)	1/4 (25%)	0/3	

***Other includes: Peripheral neuropathy, high blood pressure, low energy level,

** Symptoms not reported include: gingivitis, nephritic syndrome, renal failure, proteinuria, and salivation

Table A7. Questions regarding fish consumption for all received surveys

	Reportable Blood Mercury Level (PPB, µg/L)	Daily	Few times / week	About once / week	Less than once / week	About once / month	Less than once / month	Never	Don't know / not answered
How often do you eat fish or seafood?	5-9	3/32 (9%)	21/32 (66%)	6/32 (19%)	1/32 (3%)	1/32 (3%)	0	0	0
	10-14	1/10 (10%)	5/10 (50%)	3/10 (30%)	1/10 (10%)	0	0	0	0
	15+	3/16 (19%)	9/16 (56%)	4/16 (25%)	0	0	0	0	0
	Total	7/58 (12%)	35/58 (60%)	13/58 (22%)	2/58 (4%)	1/58 (2%)	0	0	0

Table A7. 1. Questions regarding fish consumption for patients retested with returned surveys

	Reportable Blood Mercury Level (PPB, µg/L)	Few times / week	About once / week	Less than once / week
How often do you eat fish or seafood?	5-9	2/3	1/3	0/3
	10-14	3/4	0/4	1/4
	15+	3/3	0/3	0/3
	Total	8/10	1/10	1/10

Table A7.2. Questions regarding fish consumption: frequency of consumption for all received surveys

	Reportable Blood Mercury Level (PPB, µg/L)	More	Less	No Change	Don't know / not answered
Were you eating more or less fish or seafood before you saw your doctor and had the mercury test?	5-9	4/32 (13%)	2/32 (6%)	26/32(81%)	0
	10-14	2/10 (20%)	1/10 (10%)	7/10(70%)	0
	15+	6/16 (37%)	3/16 (19%)	7/16 (44%)	0
	Total	12/58 (21%)	6/58 (10%)	40/58 (69%)	0

Table A7.3. Questions regarding fish consumption: frequency of consumption for patients retested with returned surveys

	Reportable Blood Mercury Level (PPB, $\mu\text{g}/\text{L}$)	More	Less	No Change	Don't know / not answered
Were you eating more or less fish or seafood before you saw your doctor and had the mercury test?	5-9	1/3	0/3	2/3	0
	10-14	1/4	1/4	2/4	0
	15+	1/3	0/3	2/3	0
	Total	3/10	1/10	6/10	0

Table A7.4. Questions regarding fish consumption: origin of fish consumed

	Reportable Blood Mercury Level (PPB, $\mu\text{g}/\text{L}$)	Grocery Store	Restaurant	Caught	Don't know / not answered
Where do the fish you eat normally come from? (More than 1 answer OK)	5-9	14/32 (44%)	2/32 (6%)	1/32 (2%)	0
	10-14	1/10 (10%)	0	0	0
	15+	6/16 (37)	1/16 (6%)	1/16 (6%)	1/16 (6%)
	Total	21/58 (36%)	3/58 (5%)	2/58 (3%)	1/58 (3%)

Note: The majority of the respondents use multiple sources for their fish consumption

Table A7.5. Questions regarding fish consumption: preparation or preservation of fish

	Reportable Blood Mercury Level (PPB, $\mu\text{g}/\text{L}$)	Canned	Fresh	Frozen	Don't know / not answered
If fish usually come from a <i>grocery store</i> , how is the fish packaged? (More than 1 answer OK)	5-9	2/32 (6%)	12/32 (37%)	3/32 (9%)	3/32 (9%)
	10-14	0	7/10 (70%)	1/10 (10%)	0
	15+	0	7/16 (44%)	2/16 (12%)	1/16 (6%)
	Total	2/58 (3%)	26/58 (45%)	6/58 (10%)	4/58 (7%)

Note: 20/58 had at list 2 options listed

Table A 8. Questions regarding potential occupational exposures

	Reportable Blood Mercury Level (PPB, µg/L)	Yes	No	Don't know/ not answered
In the last 2 years have you, or someone in your household, worked in the following places?	5-9	3/32 (9%)	29/32 (91%)	0
	10-14	1/10 (10%)	9/10 (90%)	0
	15+	2/16 (13%)	14/16 (87%)	0
	Total	6/58 (10%)	52/58 (90%)	0

Table A8.1. Questions regarding potential occupational exposures: specific industry with most occupations listed

Listed Workplace – N=3				
Reportable Blood Mercury Level (PPB, µg/L)	Healthcare	Education	Businesss	All others listed
5-9	3/32(9%)	4/32(13%)	2 (6%)	23/32 (72%)
10-14	1/10 (10%)	0	5 (50%)	4/10 (40%)
15+	2/16 (6%)	1/16 (6%)	1 (6%)	13/16 (82%)
Total	6/58 (7%)	5/58(9%)	8/58 (24%)	42/58 (72%)

All others include: Engineering, Sales, Science, Service, Arts, computer, Financial, Self-employed, Sports, and retired

Table A9. Questions regarding other potential exposures

	Reportable Blood Mercury Level (PPB, µg/L)	Yes	No	Don't know/ not answered
Have you participated in any of the following activities recently?	5-9	6/32 (28%)	23/32 (72%)	3
	10-14	3/10 (40%)	6/10 (60%)	1
	15+	4/16 (37%)	10/16 (63%)	2
	Total	13/58(33%)	39/58 (67%)	0

Table A9.1. Questions regarding other potential exposures: listed activities

Listed Practice or Activity - N=6, MORE THAN ONE SELECTION OK						
Reportable Blood Mercury Level (PPB)	Folk Medicine	Folk Medicine/ Herbal Remedies	Herbal remedies	Fluorescents Bulbs	Photography development	All others listed
5-9	0	2	2	0	1	1
10-14	0	2	0	1	0	0
15+	2	0	0	2	0	0
Total	2	4	2	3	1	1

Table A10. PCP location used as a proxy for location of cases

PCP County	Count
Adams	6
Arapahoe	67
Boulder	190
Chaffee	1
Delta	4
Denver	36
Douglas	27
Eagle	3
El Paso	120
Fremont	7
Garfield	7
Jefferson	16
La Plata	2
Larimer	49
Logan	5
Mesa	12
Moffat	3
Montrose	3
Pitkin	20
Routt	4
San Miguel	2
Teller	3
Total	587

Bold values represent Denver metro area

Appendix – B: Follow-up Survey



Colorado Department
of Public Health
and Environment

Adult Survey

Name:

Date of Birth:

CONSENT: Laboratories are required to report clinical test results of mercury to the Colorado Department of Public Health and Environment. We follow up on these reports to investigate possible health problems associated with mercury, so we can take actions to reduce/prevent exposures. Sometimes this effort can also help prevent others from getting sick. According to a laboratory report, you recently had a mercury test. In order for us to do our investigation we need some information from you. We would like to ask you some questions about the potential sources of mercury exposure and your medical care. The questions take about 20 minutes and you are free to decline to participate.

There is no risk or direct benefit to you and the facts we collect will be kept private to the level allowed by law. You may refuse to answer any questions or stop the survey at any time. You may contact Raj Goyal at 303-692-2634, if you have any questions about the investigation.

Please check the appropriate response and provide additional details where applicable.

1) Our records indicate that you had a blood/urine test for mercury on 01/07/2011. Were you ever notified of the result?

Yes

No

Don't know

2) Do you know why your doctor tested for mercury?

Yes Explain: _____

No

3) Why did you go to the doctor originally?

Reason for visit: _____

Don't know

4) Do you know how you were exposed to mercury?

Yes Explain: _____

No

Don't know

5) Have you had any previous mercury testing in the last 5 years?

Yes Date (if known): _____

Reason (if known): _____

No

Don't know

6) Do you have another mercury test scheduled?

Yes Date (if known): _____

No

Don't know

7) During your original visit, did your doctor identify any of the following signs or symptoms? **(Please check all that apply in the table below)**

Yes

No

Don't know

Signs/Symptoms			
Headache	<input type="checkbox"/>	Incoordination	<input type="checkbox"/>
Weakness	<input type="checkbox"/>	Short-term memory loss	<input type="checkbox"/>
Malaise	<input type="checkbox"/>	Impaired sense of smell	<input type="checkbox"/>
Blurred vision	<input type="checkbox"/>	Leg cramps	<input type="checkbox"/>
Social withdrawal	<input type="checkbox"/>	Gingivitis	<input type="checkbox"/>
Numbness/tingling	<input type="checkbox"/>	Nephritic syndrome	<input type="checkbox"/>
Impaired hearing	<input type="checkbox"/>	Renal failure	<input type="checkbox"/>
Tremor	<input type="checkbox"/>	Proteinuria	<input type="checkbox"/>
Other (explain)	<input type="checkbox"/>		<input type="checkbox"/>

8) What is your current occupation?

Describe: _____

9) Where is your place of work (name / industry / location)?

Describe: _____

10) In the last 2 years have you, or someone in your household, worked in any of the following places? **(Please list in the table below)**

Yes

No

Don't know

Work Place	Self	Other (who?)	Job Title
<input type="checkbox"/> Mine			
<input type="checkbox"/> Dental Practice			
<input type="checkbox"/> Electrical or electronic factory			
<input type="checkbox"/> Laboratory			
<input type="checkbox"/> Hospital or Doctors' Surgery			
<input type="checkbox"/> Coal power plant or production process			
<input type="checkbox"/> Industry making gas pressure regulators (gas meters)			
<input type="checkbox"/> Waste disposal or incineration site			
<input type="checkbox"/> Fluorescent tube or chemical production plant			
<input type="checkbox"/> Chloralkali plant			
<input type="checkbox"/> Thermometer manufacturing plant			
<input type="checkbox"/> Crematory			
<input type="checkbox"/> Any other place using mercury			

11) How long have you lived at your current permanent address? **(Please check one box)**

Number of years: _____

Don't know

12) What type of home do you live in? **(Please check one box)**

Single family, townhouse, duplex,

Mobile or modular home

Apartment or condominium

Other-Describe _____

Don't know

13) Do you have any children younger than 7 who either live with you, or who frequently visit you? **(Please check one box)**

Yes

No

Don't know

14) In the past year, are you aware of any mercury spills that your child may have come in contact with? Examples of mercury spills include broken thermometers, dial thermostats, broken compact fluorescent light bulbs (CFLs). **(Please check one box)**

Yes

No

If you are aware of a spill:

When did this spill occur? Date: _____ Don't know

Who cleaned up the spill? _____ Don't know

How was the spill cleaned? _____ Don't know

15) Have these children ever been tested for mercury? **(Please check one box)**

Yes

Name(s): _____

Age(s): _____

Result(s): _____

No

Don't know

16) Is anyone in the house pregnant or nursing? **(Please check one box)**

Yes

Pregnant: _____

Nursing: _____

No

Don't know

17) How often do you eat fish or seafood? **(Please check one box)**

Never

Daily

About once/week

Few times/week

About once/month

Less than
once/month

Don't know

Less than once/week

18) What portion of fish do you usually eat per meal? 1 portion = 6 oz of cooked fish and 8 oz of uncooked fish (i.e., a portion approximately the size of the palm of your hand or a deck of cards).

Describe: _____

19) Were you eating more or less fish or seafood before you saw your doctor and had the mercury test? **(Please check one box)**

- More Describe: _____
- Less Describe: _____
- No change Don't know

20) What type of fish do you normally eat? **(Please check one box)**

List: _____ (Adding more space for people can list several types of fish)

- Don't know

21) Where do the fish you eat normally come from? **(Please check one box)**

- Grocery store Caught
- Restaurant Don't know

22) If fish usually come from a *grocery store*, how is the fish packaged? **(Please check one box)**

- Canned Frozen
- Fresh Don't know

23) If the fish is normally *caught*, where was the fish caught? **(Please check one box and describe)**

- Ocean List/describe: _____
- River/stream List/describe: _____
- Lake List/describe: _____
- Don't know

24) Have you participated in any of the following activities recently? **(Please check a box in the table below and describe)**

Yes

No

Don't know

Activity or Practice	Description
<input type="checkbox"/> Religious practices (Azogue, Santeria, Espiritismo)	
<input type="checkbox"/> Folk Medicine/ Herbal Remedies	
<input type="checkbox"/> Antiques (clocks, mirrors, lamps)	
<input type="checkbox"/> Outdated Medicine (laxatives, worming medications, teething powders)	
<input type="checkbox"/> Photography development	
<input type="checkbox"/> Broken thermometers/electrical switches	
<input type="checkbox"/> Fluorescent light bulbs	

25) How many silver amalgam dental fillings do you have? **(Please check one box)**

Yes

None

Don't know

#Fillings: __

26) **If you have silver amalgam fillings:** have any of your fillings broken in the last 6 months? **(Please check one box)**

Yes

No

Don't know

#Fillings: _____

27) When did you last visit the dentist?

Date: _____

Don't Remember

28) Could you please provide the following information so that we can update our records?

o First name: _____

o Middle name: _____

o Last name: _____

o Previous last name (if applicable): _____

o Date of Birth (mm/dd/yyyy): _____

o Gender: _____

Primary address:

- Street Number: _____
- City, State and Zip Code: _____
- Primary phone number: _____
- Alternate phone # (if applicable): _____

If you have lived at this residence for less than 6 months, please provide your previous address:

- Street Number: _____ City: _____
- State: _____ Zip: _____

Alternate address (if applicable):

- Street Number: _____
- City, State and Zip Code: _____

29) How would you describe your race or ethnicity? **(Please check one box)**

- | | |
|---|--|
| <input type="checkbox"/> White | <input type="checkbox"/> Pacific Islander |
| <input type="checkbox"/> African American | <input type="checkbox"/> Alaskan/American Indian |
| <input type="checkbox"/> Asian | <input type="checkbox"/> Other: _____ |
| <input type="checkbox"/> Hispanic | <input type="checkbox"/> Don't know |

30) What is the highest level of education that you have completed? **(Please check one box)**

- 7th grade or less
- Some high school
- High School Graduate
- Some College or Technical School
- College/ Technical School Graduate
- Graduate Degree
- Professional Degree
- Don't know