Heavy Metals Surveillance in Michigan Residents: Second Annual Report (January 2007– December 2007)

MICHIGAN STATE
U N I V E R S I T Y

Department of Medicine
117 West Fee Hall
East Lansing, MI 48823

and

Division of Environmental Health
Michigan Department of Community Health
P.O. Box 30195, Lansing, MI 48909

Jennifer M. Granholm, Governor
Janet Olszewski, Director

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Prepared by:
Matt Nester, MPH
Martha Stanbury, MSPH
Amy Krizek, BS
Kenneth Rosenman, MD

Address inquiries and correspondence to Martha Stanbury at Michigan Department of Community Health, Division of Environmental Health, PO Box 30195, Lansing MI, 48909; stanburym@michigan.gov or 517-335-335-8350.

Author affiliations: Matt Nester, Amy Krizek, and Kenneth Rosenman are with Michigan State University, Department of Medicine, 117 West Fee Hall, East Lansing, Michigan 48824-1316; 517-353-1846.
Martha Stanbury is with the Michigan Department of Community Health, Division of Environmental Health, PO Box 30195, Lansing MI 48909

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Executive Summary – Michigan Heavy Metals Surveillance Project 2007 Annual Report

- In September 2005, MDCH promulgated rules requiring laboratories to report clinical laboratory results of all arsenic, cadmium, and mercury tests in blood and urine.

- The reporting requirement was established so that MDCH could improve on the tracking and mitigation of human health impacts of environmental and occupational exposures to these heavy metals.

- Individuals with results exceeding action thresholds are contacted to determine the source of exposure to the metal and assess if public health interventions are warranted.

- The reporting period for the 2007 annual report spans 01/01/2007 through 12/31/2007.

- 13,245 total reports were received on 7013 individuals during the reporting period.

- 254 individuals had a result that exceeded one of the established action thresholds (245 adults and 9 children under the age of 16).

- Two workplace investigations were initiated, one for elevated mercury levels in five workers and one for elevated cadmium levels in ten workers. Air levels above legally permissible levels were found at both facilities, which combined employed 140 employees. Recommendations and citations were issued regarding corrective action to reduce exposures.

- Most elevated arsenic or mercury levels were associated with fish consumption. Individuals with an elevated mercury level were provided with information regarding healthy fish consumption. No such action is need for arsenic because the form of arsenic in fish does not have health effects on humans.

- The high percentage of normal results has raised the concern about the indications for ordering these tests.

- Laboratory reporting and individual follow-up are continuing in 2008.

Background

In September 2005, the Michigan Department of Community Health (MDCH) promulgated rules requiring clinical laboratories to report all clinical test results of arsenic, cadmium, and mercury in blood and urine, under the statutory authority of the Public Health Code (Appendix 1). Like other public health surveillance systems, the system built on this reporting requirement includes collection of sufficient information about tested individuals and their health care providers to conduct follow-up to identify the source of exposure, which then triggers public health actions to mitigate exposures to others, if appropriate. The reporting requirement was established so that MDCH could improve on the tracking and mitigation of human health impacts of environmental and occupational exposures to these heavy metals, including exposures from intentional acts. Two-page summaries of the health effects of arsenic, cadmium and mercury are available at the Agency for Toxic Substances and Disease Registry (ATSDR) web site[1].

Laboratories were asked to submit all arsenic, cadmium, and mercury blood and urine results for tests performed on Michigan residents. These results could be reported using form DCH-1282, a standard laboratory report form, or submitted electronically.

Registry Information

Data elements reported by the laboratories included personal identifiers, demographics, laboratory and ordering provider contact information, and clinical test results (see Appendix 1). Form DCH-1282 provides the variable information named in the metals reporting rule. Electronic reports were submitted using encrypted files, secure file exchange websites, secure file transfer protocol over secure connection directly to MDCH, or HL7 messaging. HL7 messaging capabilities are currently under development at MDCH and more laboratories will be encouraged to submit electronic messages in this format as the capacity increases. Paper report entry was prioritized so that those reports above the action threshold were entered immediately and those under the action threshold were entered in the order they were received, as time permitted. In order to complete the data entry for reports below the action threshold, a decision was made to enter a core set of data limited to: Record ID, Patient Last Name, Patient First Name, Patient Date of Birth, Patient Zip Code, Provider Last Name, Provider First Name, Test Type, Specimen Type, Result Value and Result Units.

Reports are submitted to MDCH at a minimum of once per week. These reports are compiled into a central spreadsheet and the data is cleaned to ensure the files match the variable specifications. Every month the data are sorted by date of birth and test type.

Under a data sharing agreement, Michigan State University Occupational and Environmental Medicine Division (MSU OEM) is the bona fide agent of the state for public health follow-up of heavy metals surveillance reports.

Processed reports are triaged as normal or elevated according to the following action thresholds. These thresholds were developed in consultation with the MSU OEM. Thresholds are based on the following:

[1] ATSDR, Division of Toxicology and Environmental Medicine ToxFAQs, Arsenic, September 2005: http://www.atsdr.cdc.gov/tfacts2.pdf
ATSDR, Division of Toxicology and Environmental Medicine ToxFAQs, Cadmium, June 1999: http://www.atsdr.cdc.gov/tfacts5.pdf
ATSDR, Division of Toxicology and Environmental Medicine ToxFAQs, Mercury, April 1999: http://www.atsdr.cdc.gov/tfacts46.pdf

- The arsenic urine action threshold for adults was raised in the second year of the surveillance to 50 µg/L from the 35µg/L value used in the first year. The lower value corresponds to the time weighted average air exposure to arsenic allowed by the Michigan Occupational Safety and Health Administration (MIOSHA) and is also the biologic exposure index (BEI) level established by the American Conference of Industrial Hygienists. However, the source of the arsenic with urine values between 35 and 50µg/L was fish ingestion and since arsenic in fish is nontoxic it was not an effective use of resources to interview individuals with urine arsenic levels less then 50µg/dl.

Table 1. Action thresholds identified for follow-up by test and specimen type.

Test Type	Specimen Type	Elevated
Arsenic	Blood	>70 µg/L
	Urine – adults	≥50 µg/L
	Urine – children	≥50 µg/L
Cadmium	Blood	>5 µg/L
	Urine	>2 µg/L or >3 µg/g creatinine
Mercury	Blood – adults	≥15 µg/L
	Blood – children	>10 µg/L
	Urine – adults	>20 µg/L or >35 µg/g creatinine
	Urine – children	>10 µg/L

- The arsenic urine action threshold for children is the value recommended in CDC's Case Definitions for Chemical Poisoning[2].
- The arsenic blood action threshold for adults and children corresponds to the value cited by ATSDR for use by primary care practitioners[3].
- The cadmium blood and urine action thresholds are based on requirements by MIOSHA for medical surveillance of workers with occupational cadmium exposure.
- Mercury blood and urine action thresholds for adults have been established by the American Conference of Industrial Hygienists. These thresholds are BEIs intended for the evaluation of occupational exposures in workers.
- The mercury blood and urine action thresholds for children are the values recommended in CDC's *Case Definitions for Chemical Poisoning*[2].

Individuals with test values that are at or above the action threshold are sent a letter. For children, the letter is sent to a parent or guardian. Contact information and a best time to call are established so that a metal-specific standardized questionnaire can be administered via telephone interview. Information collected during the interviews includes potential sources of environmental or occupational exposures. Health information is provided to the patient or family about limiting potential exposures. Exposures are also evaluated to determine if additional public health or occupational safety and health measures are warranted to prevent or reduce exposure to other individuals.

Print copies of this report are distributed to partner agencies and electronic copies are available on the MDCH website: http://michigan.gov/mdch-toxic.

Results

Between January 1, 2007 and December 31, 2007, MDCH received 13,245 total lab result reports into the Heavy Metals Surveillance Project on 7,013 individuals. These reports were submitted from the laboratories listed in Table 2.

[2] Belson MG, Schier JG, and Patel MM. 2005. Case Definitions for Chemical Poisoning. MMWR 54(RR01);1-24 .
[3] Agency for Toxic Substances and Disease Registry. 2000. Case Studies in Environmental Medicine: Volume 1 – Arsenic Toxicity. Atlanta: US Department of Health and Human Services. Also at http://emergency.cdc.gov/agent/mercury/mercelementalcasedef.asp

Table 2. Distribution of reports across submitting laboratories in 2007 (n=13245).

Laboratory Name	**n (%)**
ARUP	2050 (15.5)
ATW	3 (0.0)
Lab Corp of America / LabCorp Dublin	1115 (8.4)
Mayo Clinic Dept of Lab Med and Pathology	4331 (32.7)
Mayo Medical Laboratories	539 (4.1)
Quest Diagnostics Incorporated	2624 (19.8)
SBMF	119 (0.9)
Specialty Laboratories, Inc.	2156 (16.3)
Spectrum Health	7 (0.1)
Unknown	117 (0.9)
Total	13245 (100.0)

Statistics are presented summarizing all the reports by test type and specimen type for individuals who were tested. The distribution of gender is shown in Table 3. For records that did contain information on gender, more metals tests were performed on males (53.6%) than females (46.4%).

Table 3. Distribution of gender, when reported*, in 2007 (n = 6746).

Sex	**n (%)**
Male	3613 (53.6)
Female	3133 (46.4)
Total*	6746 (100)

*Gender was missing/unknown for 267 (3.8%) of all individuals (N = 7013).

Race and ethnicity information were largely unreported. The available race information is in Table 4; 86.8% of the metals reports contained no race information. Because of the large amount of missing information in this variable, race information will be excluded from further breakdowns of the data. Information on ethnicity was requested, but this information was not captured by the laboratories, thus no information on ethnicity is reported.

Table 4. Distribution of race, when reported*, in 2007 (n = 925).

Race	**n (%)**
White	835 (90.3)
Black	78 (8.4)
Asian	7 (0.8)
Mixed	5 (0.5)
Total*	925 (100)

*Race was missing/unknown for 6088 (86.8%) of the total individuals (N = 7013).

The total number of 13,245 reports received in the 2007 reporting year represent six unique test (arsenic, cadmium, mercury) and specimen type (blood and urine) combinations. Table 5 shows how many total reports were received for each of these unique combinations. The following sections discuss each of these individual combinations. However, since a single person may receive repeated tests throughout the reporting year, each subset of test and specimen type was de-duplicated such that each individual may contribute only a single report per subset. First, the records were matched on date of birth, last name, and first name. Then the highest reported level was selected for each unique, or matched, individual. As a result, the sections that follow on specific metals contain fewer individual reports than the aggregate totals shown in Table 5.

Table 5. Breakdown of reports by test and specimen type for 2007 reporting year (n= 13245).

	Specimen Type		
Test Type	Blood	Urine	Total
Arsenic	3584	1948	5532
Cadmium	1775	763	2538
Mercury	3715	1460	5175
Total	9074	4171	13245

The data in table 5a show that 21.3% of individuals had testing for all three metals, typically ordered as a heavy metal panel while most individuals had testing for a single metal.

Table 5a. Number of metals tested per individual

Metals	**n**	**(%)**
Either As, Cd, or Hg	5407	77.1
As and Cd	14	0.2
As and Hg	90	1.3
Cd and Hg	5	0.1
As, Cd, and Hg	1497	21.3
Total	7013	100.0

Most individuals (64%) who were tested had both blood and urine measurements performed (Table 5b).

Table 5b. Number of total tests in 2007 per individual

# of blood and/or urine tests	**n**	**(%)**	**Reports**
1	2528	36.0	2528
2	2875	41.0	5750
3	1497	21.3	4491
4	94	1.3	376
5	16	0.2	80
6	2	0.0	12
8	1	0.0	8
Total	7013	100.0	13245

Among the individuals who had all three metals tested, a small number 66(4.4%) had repeated tests (Table 5c).

Table 5c. Number of individuals who were tested for the heavy metals panel (at least one specimen each of As, Cd, and Hg)

Tests	**n**
3	1431
4	48
5	16
6	1
8	1
Total	1497

Few individuals had the same test repeated more than once in the same year (Table 5d).

Table 5d. Number of heavy metal tests in 2007 per individual

Test and Specimen Type	Individuals tested once	Individuals tested twice	Total Tests
As Blood	3574	5	3584
As Urine	1932	8	1948
Cd Blood	1773	1	1775
Cd Urine	701	31	763
Hg Blood	3709	3	3715
Hg Urine	1450	5	1460
Total	13139	53.0	13245

Arsenic Urine (1931 individuals tested)

Table 6. Age mean, median and range of individual Michigan residents with urine arsenic tests in 2007 (N=1917)*.

Statistic	Years
Mean	54.1
Median	55.6
Range	0.5-92.5

* 14 individuals receiving tests were missing DOB or age and were excluded from analysis.

Table 7. Gender distribution, when gender is reported, of individual Michigan residents with urine arsenic tests in 2007 (n=1828) *.

Sex	n(%)
Male	1014 (55.5)
Female	814 (44.5)
Total	1828 (100.0)

*Gender was missing/unknown in 103 (5.6%) of the total urine arsenic reports.

Table 8. Specimen type submitted for urine arsenic tests of Michigan residents in 2007 (n=1931).

Test Type	n(%)
Random Urine	1705 (88.3)
24 Hour Urine	226 (11.7)
Total	1931 (100.0)

Table 9. Mean, median, and range of urine arsenic tests in 2007 of Michigan residents (n=1931).

Statistic	Value*
Mean	23.1
Median	13.0
Range	0.0-1107.0

*Includes results measured in µg/24 Hours, µg/L, µg/specimen, and µg/g creatinine.

Table 10. Distribution of individual Michigan residents' urine arsenic results (n=1931).

Distribution Categories	n(%)
Above Action Threshold	168 (8.4)
Normal	1327 (69.0)
Non-Detect	436 (22.6)
Total	1931 (100.0)

Table 11. Number of individual Michigan residents ≥16 years of age with urine arsenic levels ≥ 50 µg/24 Hours, µg/L, µg/specimen or µg/g creatinine (n=1853).

Level	n(%)
≥ 50	162 (8.7)
Less than 50	1691 (91.3)
Total	1853 (100.0)

Table 12. Number of individual Michigan residents <16 years of age with urine arsenic levels ≥ 50 µg/24 Hours, µg/L, µg/specimen or µg/g creatinine (n= 78).

Level	n(%)
≥ 50	6 (1.3)
Less than 50	72 (98.7)
Total	78 (100.0)

Summary of Results

The mean age of individuals with urine arsenic tests was 54.1, and 55.5% of the individuals, when gender was indicated, were male. Females accounted for 44.5%.

Specimens submitted were 88.3% random urine, and 11.7% were 24-hour urine collections (Table 8).

The average result was 23.1 with a standard deviation of 52.1 (Table 9). The mean result value includes results for all test types that are measured in µg/L, µg/24 hours, µg/specimen, and µg/g creatinine. This average value is well below the action thresholds of 50 µg/L for adults' and children's arsenic urine tests.

One hundred and sixty-eight individuals (8.4%) had arsenic urine values exceeding the action thresholds. A majority of the individuals (69.0%) were reported to be in the normal range of 0-50 µg/L while 22.6% had arsenic levels that were undetectable in urine.

The high number of individuals in the normal range reflects the low levels of naturally occurring arsenic found in some common foods and well water supplies.

One hundred and sixty-two individuals over the age of 16 exceeded the arsenic action threshold and 85 have been interviewed. Among those interviewed, seafood was the source identified for 80 (94.1%), well water for 3 (3.5%) and work exposure for 2 (2.4%). The levels attributed to seafood were presumably organic arsenic, which does not have a toxic effect. The other individuals with elevated arsenic who were interviewed were below levels where symptoms of arsenic toxicity have been reported in the medical literature. Six individuals under the age of sixteen exceeded the action threshold.

Arsenic Blood (3576 individuals tested)

Table 13. Age mean, median, and range of individual Michigan residents with blood arsenic tests in 2007 (n= 3571*).

Statistic	Years
Mean	49.1
Median	50.7
Range	0- 99.7

*5 individuals receiving tests were missing DOB or age and were excluded from analysis.

Table 14. Gender distribution, when gender is reported*, of individual Michigan residents with blood arsenic tests in 2007 (n= 3478).

Sex	N(%)
Male	1855 (46.7)
Female	1623 (53.3)
Total	3478 (100.0)

*Gender was missing/unknown in 98 (2.8%) of the total blood arsenic reports

Table 15. Mean, median, and range of blood arsenic tests in 2007 of individual Michigan residents (n= 3576).

Statistic	µg/L
Mean	2.8
Median	0.5
Range	0- 60

Table 16. Distribution of individual Michigan residents' blood arsenic results (n= 3576).

Distribution Categories	n(%)
Above Action Threshold	0 (0.0)
Normal	1937 (54.2)
Non-Detect	1639 (45.8)
Total	3576 (100.0)

Summary of Results

The demographic statistics of individuals receiving blood arsenic tests shown in Tables 13 and 14 differ slightly from those of the urine arsenic results shown previously. The mean age of individuals with blood arsenic tests is nearly 5 years younger than individuals with urine arsenic tests (49.1 vs. 54.1) and there were fewer females tested than males (46.7% vs. 53.3%) where gender was known.

The mean result value was 2.8 µg/L which once again was well below the established action threshold of 70 µg/L.

No individuals were reported to exceed the 70 µg/L action threshold and the reported values were evenly split between normal and non-detect (Table 16).

No contact was attempted for individuals with blood arsenic tests since all levels were below the action threshold.

Cadmium Urine (713 individuals tested)

Table 17. Age mean, median, and range of individual Michigan residents with urine cadmium tests in 2007 (n= 693*).

Statistic	Years
Mean	48.3
Median	48.3
Range	0-92.5

*20 individuals receiving tests were missing DOB or age and were excluded from analysis.

Table 18. Gender distribution, when gender is reported*, of individual Michigan residents with urine cadmium tests in 2007 (n= 646).

Sex	n(%)
Male	384 (59.4)
Female	262 (40.6)
Total	646 (100.0)

*Gender was missing/unknown in 67 (9.4%) of the total urine cadmium reports

Table 19. Specimen type submitted for urine cadmium tests of Michigan residents in 2007 (n= 713).

Test Type	n(%)
Random Urine	656 (92.0)
24 Hour Urine	57 (8.0)
Total	713 (100.0)

Table 20. Mean, median, and range of urine cadmium tests in 2007 of individual Michigan residents (n= 713).

Statistic	Value*
Mean	1.0
Median	0.1
Range	0.0- 177.8

*Includes results measured in µg/24 Hours, µg/L, µg/specimen, and µg/g creatinine.

Table 21. Distribution of individual Michigan residents' urine cadmium results (n= 713).

Distribution Categories	n(%)
Above Action Threshold	35 (4.9)
Normal	323 (45.3)
Non-Detect	355 (49.8)
Total	713 (100.0)

Summary of Results

The mean age of individuals receiving urine cadmium tests was 48.3, and where gender was indicated, 59.4% were male and 40.6% female.

The mean result value for all urine tests (µg/L, µg/24 hours, µg/specimen, and µg/g creatinine) was 1.0.

A total of 35 (4.9%) individuals exceeded the action threshold for cadmium in urine. Thirty individuals had urine cadmium levels exceeding the 2 µg/L action threshold and 5 individuals were reported with urine cadmium creatinine exceeding 3 µg/g creatinine.

None of the individuals with levels exceeding the action threshold were under the age of 16. Follow-up with individuals was only conducted on adults. Among those adults, 12 have been interviewed. The source of cadmium identified was smoking of cigarettes in three individuals (25.0%) and work exposure in nine individual (75.0%).

Cadmium Blood (1772 individuals tested)

Table 22. Age mean, median, and range of individual Michigan residents with blood cadmium tests in 2007 (n= 1771*).

Statistic	**Years**
Mean	48.2
Median	48.1
Range	0.0- 92.5

*1 individual receiving tests were missing DOB or age and were excluded from analysis.

Table 23. Gender distribution, when gender is reported*, of individual Michigan residents with blood cadmium tests in 2007 (n= 1768).

Sex	**n(%)**
Male	1010 (57.1)
Female	758 (42.9)
Total	1768 (100.0)

*Gender was missing/unknown in 4 (0.0%) of the total blood cadmium reports.

Table 24. Mean, median, and range of blood cadmium tests in 2007 of individual Michigan residents (n= 1772).

Statistic	**µg/L**
Mean	0.7
Median	0.3
Range	0.0- 178.2

Table 25. Distribution of individual Michigan residents' blood cadmium results (n= 1772).

Distribution Categories	**n(%)**
Above Action Threshold	8 (0.5)
Normal	1197 (67.6)
Non-Detect	567 (32.0)
Total	1772 (100.0)

Summary of Results

The demographics of individuals receiving blood cadmium tests were consistent with those that received urine cadmium tests. The mean age was 48.2 (Table 22) and a male to female ratio with approximately twice as many males being tested as females 57.1% vs. 42.9% (Table 23). A very small number of individuals had no gender information reported.

The mean blood cadmium level was 0.7 µg/L compared to the action threshold of 5 µg/L.

The distribution of blood cadmium results shows 8 individuals exceeded the action threshold, but most remained in the normal range. Thirty-two percent of those tested had levels below the laboratories level of detection.

No children under the age of 16 were reported with a blood level exceeding 5.0 µg/L. Seven of the eight adults have been interviewed. The source of cadmium identified was smoking of cigarettes in four individuals (57.1%), work exposure in two individuals (28.6%), and chelation in one individual (14.3%).

A follow up workplace investigation was conducted at a facility that performed cadmium plating. The investigation was initiated because of elevated cadmium levels on ten people from the same worksite in 2006 and 2007. The company was cited for having air levels above the MIOSHA time weighted average of 5.0 $\mu g/m^3$ in both the cadmium as well as the nickel-plating areas. Other deficiencies noted included: lack of periodic air monitoring; lack of provision of respirators; improper handling of contaminated work clothes; improper handling of cadmium contaminated training; lack of worker training; and lack of required medical testing to assess kidney function. There were 60 workers at this facility.

Mercury Urine (1453 individuals tested)

Table 26. Age mean, median, and range of individual Michigan residents with urine mercury tests in 2007 (n=1442*).

Statistic	**Years**
Mean	53.1
Median	53.9
Range	0.0- 92.5

*11 individuals receiving tests were missing DOB or age and were excluded from analysis.

Table 27. Gender distribution, when gender is reported*, of individual Michigan residents with urine mercury tests in 2007 (n = 1350).

Sex	**n(%)**
Male	756 (56.0)
Female	594 (44.0)
Total	1350 (100.0)

*Gender was missing/unknown in 103 (7.1%) of the total urine mercury reports

Table 28. Specimen type submitted for urine mercury tests of Michigan residents in 2007 (n= 1453).

Test Type	**n(%)**
Random Urine	1275 (87.7)
24 Hour Urine	178 (12.3)
Total	1453 (100.0)

Table 29. Mean, median, and range of urine mercury tests in 2007 of individual Michigan residents (n= 1453).

Statistic	**Value***
Mean	0.5
Median	0.0
Range	0.0- 95.0

*Includes results measured in µg/24 Hours, µg/L, µg/specimen, and µg/g creatinine.

Table 30. Distribution of individual Michigan residents' urine mercury results (n= 1453).

Distribution Categories	**n(%)**
Above Action Threshold	6 (0.4)
Normal	284 (19.5)
Non-Detect	1163 (80.0)
Total	1453 (100.0)

Table 31. Number of individual Michigan residents <16 years of age with urine mercury levels >10 µg/L (n= 36).

Level	**n(%)**
>10	1 (2.8)
10 and under	35 (97.2)
Total	36 (100.0)

Summary of Results

The mean age of individuals receiving urine mercury tests was 53.1 years (Table 26). Where gender is known, more tests were performed on men than on women (56.0% vs. 44.0%) (Table 27). Gender was missing on 7.1% of test reports.

Most of the results (87.7%) came from random urine tests.

The mean result value was 0.5 for tests measured in µg/L, µg/24 hours, µg/specimen, and µg/g creatinine.

The distribution of results showed six urine mercury levels exceeding the action threshold and a majority of the remaining values were recorded as a laboratory non-detect.

One of the 194 urine mercury creatinine tests exceeded the 35 µg/g creatinine action threshold for follow-up.

Five of the six values exceeding the action threshold were reported in individuals over the age of 16. Two of these individuals have been interviewed. Seafood was identified as the source of exposure for both adults.

Mercury Blood (3705 individuals tested)

Table 32. Age mean, median, and range of individual Michigan residents with blood mercury tests in 2007 (n= 3700*).

Statistic	Years
Mean	48.3
Median	50.3
Range	0.0- 99.7

*5 individuals receiving tests were missing DOB or age and were excluded from analysis.

Table 33. Gender distribution, when gender is reported*, of individual Michigan residents with blood mercury tests in 2007 (n = 3589).

Sex	n(%)
Male	1872 (52.2)
Female	1717 (47.8)
Total	3589 (100.0)

*Gender was missing/unknown in 116 (3.1%) of the total blood mercury reports.

Table 34. Mean, median, and range of blood mercury tests in 2007 of individual Michigan residents (n= 3705).

Statistic	µg/L
Mean	1.4
Median	0.0
Range	0.0- 68.6

Table 35. Distribution of individual Michigan residents' blood mercury results (n= 3705).

Distribution Categories	n(%)
Above Action Threshold	37 (1.0)
Normal	1714 (46.3)
Non-Detect	1954 (52.7)
Total	3705 (100.0)

Table 36. Number of individual Michigan residents <16 years of age with blood mercury levels >10 µg/L (n= 341).

Level	n(%)
>10	2 (0.6)
10 and under	339 (99.4)
Total	341 (100.0)

Table 37. Number of individual Michigan residents with blood mercury levels ≥30 µg/L (n= 3705).

Level	n(%)
≥30	9 (0.2)
Less than 30	3696 (99.8)
Total	3705 (100.0)

Summary of Results

The mean age of individuals receiving blood mercury tests was lower than those receiving urine mercury tests (48.3 vs. 50.3 years).

The male to female ratio was nearly even at 52.2% vs. 47.8% for those individuals where gender was indicated. Some of the individuals (3.1)% were missing gender information.

The mean result value was 1.4 µg/L (Table 34).

In the distribution of result values, 35 individuals exceeded the action threshold and of the remaining results there were slightly fewer normal values than laboratory non-detect.

Thirty-five individuals exceeded the Heavy Metals Reporting Project's action threshold and of those , 9 individuals exceeded the Environmental Protection Agency's (EPA) level of concern, ≥30 µg/L (Table 37). This level was indicated as a level of interest to the EPA via personal communication with Maureen O'Neill[4].

Twenty-nine adults have been interviewed. The source of mercury identified was seafood ingestion in 25 individuals (83.3%), face cream in one individual (3.4%) and work exposure in one other (3.4%).

Two children under the age of sixteen had a blood mercury level exceeding 10 µg/L.

A follow up workplace investigation was conducted at an electrical switch and relay manufacturer. The investigation was initiated because of elevated mercury levels on five people. The company was cited for having air levels above the MIOSHA time weighted average of 0.05 $\mu g/m^3$. The source of exposure was determined to be the mercury vacuum, which was used for clean up, that was releasing mercury into the air. The other source was the local exhaust ventilation, which was on a timer and would shut on and off at predetermined intervals, even though the manufacturing process was ongoing. There were 80 workers at this facility.

The County Health Department followed up on the face cream contaminated with mercury. The face cream was being made by an individual in their home and distributed to members of the Chinese community.

[4] Maureen O'Neill is a Senior Policy Advisor with the US Environmental Protection Agency, Office of the Regional Administrator.

Follow-up Activities in 2007

In total, 254 individuals were identified through the Heavy Metals Surveillance project with an elevated level of arsenic, cadmium, or mercury where an attempt to determine the source of the metal was considered to be of possible public health significance. The distribution of these individuals according to their age group and specific subset of metal and test type is summarized in Table 38. Nine children exceeded the established action threshold for follow-up.

Table 38. Number of individuals by age, exceeding action threshold and requiring follow-up for each subset of test and specimen type.

	Test and Specimen Type						
Age	AsU	AsB	CdU	CdB	HgU	HgB	Total
16 and over	162	0	35	7	5	35	245
< 16	6	0	0	0	1	2	9
Total	168	0	35	7	6	37	254

Follow-up interviews have been conducted on 132 of the 254 individuals with values exceeding the action threshold. Table 39 summarizes the sources of the metals for the one hundred and thirty-two individuals interviewed. Educational material was provided to individuals with elevated mercury from seafood ingestion. Individuals with elevated arsenic levels who indicated that they drank well water were mailed a brochure about arsenic in wells.

Table 39. Number of Adults exceeding action threshold where source of exposure has been identified, Michigan 2007.

	Test and Specimen Type						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
Seafood	80	0	-	-	2	25	107
Work-Related	2	0	9	2	0	1	14
Well Water	3	0	-	-	-	-	3
Cigarette Smoking	-	-	3	4	-	-	7
Chelation	0	0	0	1	0	0	1
Face Cream	-	-	-	-	-	1	1
Total	85	0	12	7	2	27	133

Summary

Problems related to the initial start-up of the system were resolved in year two of the project. Most laboratories have switched to electronic reporting leaving a more manageable amount of data entry from paper reports. Additional efforts are underway to encourage all laboratories to submit electronic reports. These changes have resulted in significant improvement to data quality in the second year of the project.

The volume of reports and the high percentage of normal values have raised questions about what is the indication for ordering the tests. We analyzed the 2007 data to assess the number of individuals for whom a heavy metals panel was done, compared to testing for a single metal. Approximately 20% of people had all three heavy metals checked. It is likely in these individuals that the health care provider ordered the metal testing without taking an exposure history since it would be unusual for a history to suggest exposure to all three metals. We plan to evaluate the specialty of the providers ordering the samples for testing and will be exploring the feasibility of a survey for more information on the indication for the testing. The goal of this survey will be to develop a targeted education campaign to assist healthcare providers in determining the indications for ordering testing for heavy metals and the indications when a single test vs. panel of all three tests would be clinically useful. Finally, we will also

assess if health care providers need educational material to help in the interpretation of the laboratory results.

Table 40 shows the combined data for those individuals above the action threshold for 2006 and 2007 for the two years the heavy metals registry has been in existence.

Table 40. For 2006 and 2007, number of individuals by age, exceeding action threshold and requiring follow-up for each subset of test and specimen type.

	Test and Specimen Type						
Age	AsU	AsB	CdU	CdB	HgU	HgB	Total
16 and over	428	0	78	29	8	79	622
< 16	8	0	0	1	1	3	13
Total	436	0	78	30	9	82	635

To date, 240 individuals have been interviewed. Table 41 summarizes the sources of the metals for the 240 individuals interviewed. Ingestion of seafood was the predominant source of elevated levels with elevated arsenics being the source for 75% of the individuals. Because the form of arsenic in fish is not harmful and no public health follow up is indicated, we used an action threshold of 50 µg/L in 2007 as compared to 35µg/l in 2006. We raised it again in 2008 to 100µg/l. This will allow us to concentrate on individuals who have levels more likely requiring public health follow up. Educational material was provided to individuals with elevated mercury from seafood ingestion as well as to individuals with elevated arsenic levels where well water was the suspected source.

Table 41. Number of Adults exceeding action threshold where source of exposure has been identified, Michigan 2006 and 2007.

	Test and Specimen Type						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
Seafood	143	0	-	-	2	46	191
Work-Related	4	0	10	5	0	7	26
Well Water	5	0	-	-	-	-	5
Cigarette Smoking	-	-	6	9	-	-	15
Herbal Supplement	0	0	0	0	0	1	1
Chelation	0	0	0	1	0	0	1
Face Cream	-	-	-	-	-	1	1
Total	152	0	16	15	2	55	240

Although only a relatively small percentage of elevated heavy metals were caused by workplace exposures, investigations that followed up the elevated levels that occurred from workplace exposures were the most successful interventions at identifying on-going exposures that were amenable to correction.

MDCH and MSU will continue to explore the data for environmental, occupational, and acute poisoning events effecting Michigan residents. The data will be used when indicated to conduct interventions to reduce exposures and potential adverse health affects to both the individuals with the elevated metal levels as well others who because of similar circumstances face similar risks.

Appendix I

DEPARTMENT OF COMMUNITY HEALTH

BUREAU OF EPIDEMIOLOGY
DIVISION OF ENVIRONMENTAL AND OCCUPATIONAL EPIDEMIOLOGY

HEAVY METAL AND PESTICIDE ANALYSIS REPORTING

Filed with the Secretary of State on 9/23/2005
These rules take effect immediately after filing with the Secretary of State

(By authority conferred on the director of the department of community health by sections 5111 and 2226(d) of 1978 PA 368, section 8 of 1978 PA 312, and Executive Reorganization Order Nos. 1996-1 and 1997-4, MCL 333.5111, 333.2226(d), 325.78, 330.3101, and 333.26324)

R 325.61 to R 325.68 are added to the Michigan Administrative Code as follows:

R 325.61 Definitions.
Rule 1. (1) As used in these rules:
(a) "Heavy metal analysis report form" means the form used to report the required reportable information for blood and urine that has been analyzed for arsenic, cadmium, or mercury.
(b) “Pesticide poisoning report form” means the form used to report the required reportable information for blood that has been analyzed for acetylcholinesterase or pseudocholinesterase.
(c) “Pesticide” means any substance or mixture of substances including inert ingredients and adjuvants used to prevent, destroy, mitigate, or repel any pest. Pesticides include, but are not limited to, insecticides, herbicides, fungicides, rodenticides, repellents, fumigants, wood treatment products, and disinfectants.
(d) "Department" means the Michigan department of community health.
(e) "Physician/provider" means a person who is licensed under Article 15 of the public health code MCL 333.16101 to 333.18838 who provides health care services and who is authorized to request the analysis of blood and urine specimens.

R 325.62 Reportable information.
Rule 2. (1) Reportable information is specifically related to blood and urine samples submitted to clinical laboratories for analysis.
(2) Upon initiating a request for analysis of arsenic, cadmium, mercury, acetylcholinesterase, or pseudocholinesterase, the physician/provider ordering the analysis shall complete the client information (section I) and the physician/provider information (section II) of a heavy metal analysis report form or pesticide poisoning report form designated by the department. Or, the physician/provider shall complete a similar form that ensures the inclusion of the same required data and provide all of the following information:

(a) All of the following information with respect to the individual tested:
(i) Name.
(ii) Sex, if available.
(iii) Race, if available.
(iv) Ethnic group, if available.
(v) Birthdate or age.
(vi) Address.
(vii) Telephone number.
(viii) If the individual is a minor, then the name of a parent or guardian.
(ix) If the individual is an adult, then the name and address of his or her employer, if available.
(b) The date the sample was collected.

(3) The heavy metal analysis report form or pesticide poisoning analysis report form, or a document with the same data, shall be submitted with the sample for analysis to a clinical laboratory that performs the analysis.

(4) Upon receipt of the blood or urine sample for analysis, the clinical laboratory shall complete the laboratory information (section III) and provide all of the information required and/or submitted by the physician/provider along with all of the following:

(a) The name, address, and phone number of the laboratory.

(b) The date of analysis.

(c) The results of the analysis. All values, normal and abnormal, shall be reported. For arsenic, blood levels shall be reported in micrograms per milliliter (µg/ml) and urine levels in micrograms per liter (µg/L). For cadmium, blood levels shall be reported as micrograms per liter (µg/L) of whole blood and urine tests shall be reported as micrograms per gram of creatinine (µg/gram creatinine) or micrograms per liter (µg/L). Mercury shall be reported as nanograms per milliliter of blood (ng/ml) and micrograms per liter (µg/L) of urine. Acetylcholinesterase shall be reported as units per gram of hemoglobin (U/g hemoglobin), and the laboratory normal range shall be included. Pseudocholinesterase levels shall be reported as units per liter (U/L) of plasma, and the laboratory normal range shall be included. Alternate units will be accepted for reporting purposes, as approved by the department.

R 325.63 Reporting responsibilities.

Rule 3. (1) All clinical laboratories doing business in this state that analyze blood or urine samples for arsenic, cadmium, mercury, acetylcholinesterase, or pseudocholinesterase shall report all results to the Department of Community Health, Bureau of Epidemiology, Division of Environmental Health, PO Box 30195, Lansing, MI 48909.* Reports shall be made within 5 working days after test completion.

(2) Nothing in this rule shall be construed to relieve a laboratory from reporting results of a blood or urine analysis for arsenic, cadmium, mercury, acetylcholinesterase, or pseudocholinesterase to the physician or other health care provider who ordered the test or to any other entity as required by state, federal, or local statutes or regulations or in accordance with accepted standard of practice, except that reporting in compliance with this rule satisfies the reporting requirements of 1978 PA 368, MCL 333.1101.

R 325.64 Electronic communications.

Rule 4. (1) A clinical laboratory may submit the data required in R 325.62 electronically to the department.

(2) For electronic reporting, upon mutual agreement between the reporting laboratory and the department, the reporting shall utilize the data format specifications provided by the department.

R 325.65 Investigation and quality assurance.

Rule 5. (1) The department, upon receiving a report under R 325.63 may investigate to determine the accuracy of the report, patient's source of exposure, and adverse health effects resulting from the exposure.

(2) Requests for individual medical and epidemiologic information to validate the completeness and accuracy of reporting are specifically authorized.

(3) The copies of the medical records shall not be recopied by the department and shall be kept in a locked file cabinet when not in use.

(4) Reports may be released to other state, local, or federal agencies for those agencies to administer and enforce provisions of laws or rules to protect individuals from exposure to hazardous levels of arsenic, mercury, cadmium, or pesticides. Confidential information may be released to another governmental agency only after execution of a signed interagency agreement assuring that the other agency will abide by the confidentiality requirements of R 325.66.

(5) Nothing in this rule shall be construed to relieve or preempt any other entities from investigating hazards associated with these substances under state, federal, or local statutes or regulations.

R 325.66 Confidentiality of reports.

Rule 6. (1) Reports submitted to the department under R 325.63 are not public records and are exempt from disclosure pursuant to the freedom of information act, 1976 PA 442, MCL 15.234, section 13(1)(d).

(2) The department shall maintain the confidentiality of all reports of all tests submitted to the department and shall not release reports or any information that may be used to directly link the information to a particular

* Address corrected from published document 9/28/2005

individual, unless the department has received written consent from the individual, or from the individual's parent or legal guardian, requesting the release of information.

(3) Medical and epidemiological information that is released to a legislative body shall not contain information that identifies a specific individual. Aggregate epidemiological information concerning the public health that is released to the public for informational purposes only shall not contain information that identifies a specific individual.

R 325.67 Heavy metal analysis report form.

Rule 7. The heavy metal analysis report form reads as follows:

MICHIGAN DEPARTMENT OF COMMUNITY HEALTH
HEAVY METAL ANALYSIS REPORT
DATA/INFORMATION REQUIRED BY ADMINISTRATIVE RULE R 325.62

I. CLIENT INFORMATION

Last name _____ First name _____ M.I. _____

Sex (M/F) _____ Race (White/Black/Asian/Pacific Islander/American Indian/Alaskan/mixed) _____

Ethnicity (Hispanic Y/N) _____ Birth date or age _____ Phone number _____

Street address _____ City _____ State/Zip Code/County _____

Name of parent or guardian if individual is a minor _____

Employer name (if adult) _____

Employer street address _____ City _____ State/Zip Code _____

II. PHYSICIAN/PROVIDER INFORMATION

Provider last name _____ First name _____ (_____) _____ Phone number

Provider street address _____ City _____ State/Zip Code _____

III. LABORATORY INFORMATION

_____ (_____)_____

Name of testing laboratory Phone number

_____ _____ _____

Laboratory street address City State/Zip Code

_____ _____

Date sample taken Date sample analyzed

Results

Sample	Arsenic	Cadmium	Mercury
Blood	_____ µg/ml	_____ µg/L	_____ ng/ml
Urine	_____ µg/L	_____ µg/gram creatinine OR _____ µg/L	_____ µg/L

MDCH – Division of Environmental Health, P.O. Box 30195, Lansing, MI 48909 • Fax number (517) 335-9775 • Phone number (517) 335-8350