Heavy Metals Surveillance in Michigan Residents: Third Annual Report (January 2008– December 2008)

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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 2008 annual report spans 01/01/2008 through 12/31/2008.

- In 2008, 17,066 total reports were received on 7,111 individuals during the reporting period. This compares to 13,245 total reports on 7,013 individuals in 2007. Arsenic reports were up 1,790, cadmium 319 and mercury 1,609.

- In 2008, 123 (1.7%) individuals had a result that exceeded one of the established action thresholds (121 adults and 2 children under the age of 16).

- In 2008, One workplace investigation was initiated, for elevated cadmium levels in 6 workers. Air samples taken at this facility were found to be above permissible levels. 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 2009.

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 submitted 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.

Reports are submitted to MDCH at a minimum of once per week. These reports are compiled into a central spreadsheet and the data are 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 (Table 1) 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 (2007) of surveillance to 50µg/L from the 35µg/L value used in the first year and was once again raised in the third year (2008) to 100µg/L. The 35µg/L 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 arsenic exposure in individuals with urine values between 35 and 100µg/L was fish ingestion and since arsenic in fish is nontoxic it has not been an effective use of resources to interview individuals with urine arsenic levels less then 100µg/L.

Table 1. Action thresholds identified for follow-up by test and specimen type, 2008

Test Type	Specimen Type	Elevated
Arsenic	Blood	>70 µg/L
	Urine – adults	≥100 µg/L
	Urine – children	≥100 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: www.michigan.gov/mdch-toxic, and the MSU website: www.oem.msu.edu.

Results

Between January 1, 2008 and December 31, 2008, MDCH received 17,066 total lab result reports into the Heavy Metals Surveillance Project on 7,111 individuals. These reports were submitted from the ten 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 2008 (n = 17,066).

Laboratory Name	n (%)
Advanced Toxicology Network	5 (0.0)
ARUP	2,143 (12.6)
ATW	1 (0.0)
Lab Corp of America	2,492 (14.6)
Mayo Clinic	7,319 (42.9)
Nichols Institute	3 (0.0)
NMS Labs	2 (0.0)
Quest Diagnostics Incorporated	2,531 (14.8)
SBMF	78 (0.5)
Specialty Laboratories, Inc.	2,454 (14.4)
Spectrum Health	35 (0.2)
Unknown	3 (0.0)
Total	17,066 (100.0)

Statistics are presented summarizing all the reports and statistics by test type and specimen type by individuals who were tested. The distribution of gender is shown in Table 3. For records that did contain information on gender, tests were more often performed on males (55.1%) than females (44.9%).

Table 3. Distribution of gender, when reported*, in 2008 (n = 7,050).

Sex	n (%)
Male	3,886 (55.1)
Female	3,164 (44.9)
Total*	7,050 (100.0)

*Gender was missing/unknown for 61 (0.9%) of the total individuals (N = 7,111).

Race and ethnicity information were largely unreported. The available race information is in Table 4; 77.0% 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 2008 (n=1,632).

Race	n (%)
White	1,545 (94.6)
Black	76 (4.7)
Asian	7 (0.4)
Native American	2 (0.1)
Mixed	2 (0.1)
Total*	1,632 (100.0)

*Race was missing/unknown for 5,479 (77.0%) of the total individuals (n=7,111).

The total number of 17,066 reports received in the 2008 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 2008 reporting year (n=16,963)*.

	Specimen Type		
Test Type	Blood	Urine	Total
Arsenic	4,718	2,604	7,322
Cadmium	2,369	488	2,857
Mercury	5,034	1,750	6,784
Total	12,121	4,842	16,963

*Test type and/or specimen type was missing for 103 (0.6%) of the total reports (n=17,066).

The data in table 5a show that 26.6% of individuals had testing for all three metals, typically ordered as a heavy metal panel while most individuals (45.5%) had testing done for both arsenic and mercury.

Table 5a. Types of metal(s) tested per individual (n=7,111)

Metals	n	(%)
Either As, Cd, or Hg	1,894	26.6
As and Cd	91	1.3
As and Hg	3,233	45.5
Cd and Hg	47	0.7
As, Cd, and Hg	1,842	25.9
Total	7,111	100.0

Most individuals (44.6%) who were tested had two blood and/or urine measurements performed (Table 5b).

Table 5b. Number of total tests in 2008 per individual (n=17,066)

# of blood and/or urine tests	Individuals	(%)	Reports
1	1,513	21.3	1,513
2	3,172	44.6	6,344
3	1,658	23.3	4,974
4	277	3.9	1,108
5	73	1.0	365
6	324	4.6	1,944
7	23	0.3	161
8	30	0.4	240
9	20	0.3	180
10	8	0.1	80
11	5	0.1	55
12	5	0.1	60
14	3	0.0	42
Total	7,111	100.0	17,066

Among the individuals receiving tests, the most common specimen taken was blood, over two-thirds (67.3%) of all tests (Table 5c). .

Table 5c. Tests by specimen type per individual in 2008 (n=7,111)

Tests	N	%
Blood and Urine	435	6.1
Blood only	4,783	67.3
Urine only	1,841	25.8
Not reported	52	0.7
Total	7,111	100.0

For individuals who were only tested once, the most common test and specimen combination was mercury blood (3,969). Cadmium urine tests were the least common type of testing performed among individuals in 2008 (344). (Table 5d).

Table 5d. Number of heavy metal tests* in 2008 per individual (n=16,841)

Test and Specimen Type	Individuals tested once	Tested two times	Tested three times	Tested four times	Total Tests
As Blood	3,756	424	34	3	4,718
As Urine	1,629	296	35	39	2,482
Cd Blood	1,653	321	22	2	2,369
Cd Urine	344	58	4	4	488
Hg Blood	3,969	472	35	4	5,034
Hg Urine	1,264	159	18	16	1,750
Total	12,543	1,694	144	68	16,841

*Test or specimen type was missing for 71 individuals, for a total of 225 tests.

Arsenic Urine (2,067 individuals tested)

Table 6. Age mean, median and range of individual Michigan residents with urine arsenic tests in 2008 (N=2,051)*.

Statistic	Years
Mean	53.7
Median	54.2
Range	1.3 – 93.0

*16 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 2008 (n=2,039) *.

Sex	n (%)
Male	1,139 (55.9)
Female	900 (44.1)
Total	2,039 (100.0)

*Gender was missing/unknown in 28 (1.4%) of the total urine arsenic reports.

Table 8. Specimen type submitted for urine arsenic tests of Michigan residents in 2008 (n=2,067).

Test Type	n (%)
Random Urine	1,767 (85.5)
24 Hour Urine	300 (14.5)
Total	2,067 (100.0)

Table 9. Mean, median, and range of urine arsenic tests in 2008 of Michigan residents (n=2,067).

Statistic	Value*
Mean	17.7
Median	11.0
Range	0.0 – 470.0

*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=2,067).

Distribution Categories	n (%)
Above Action Threshold	50 (2.4)
Normal	1,421 (68.7)
Non-Detect	596 (28.9)
Total	2,067 (100.0)

Table 11. Number of individual Michigan residents ≥16 years of age with urine arsenic levels ≥ 100 µg/24 Hours, µg/L, µg/specimen or µg/g creatinine (n=2,007).

Level	n (%)
≥ 100	50 (2.5)
Less than 100	1,957 (97.5)
Total	2,007 (100.0)

Table 12. Number of individual Michigan residents <16 years of age with urine arsenic levels ≥100 µg/24 Hours, µg/L, µg/specimen or µg/g creatinine (n=30).

Level	n	(%)
≥ 100	0	(0.0)
Less than 50	30	(100.0)
Total	30	(100.0)

Summary of Results

The mean age of individuals with urine arsenic tests was 53.7. When gender was given, 55.9% of the individuals were male. Females accounted for 44.1%.

Specimens submitted were 85.5% random urine, and 14.5% were 24-hour urine collections (Table 8).

The average result was 17.7µg/L (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 threshold for adults' and children's arsenic urine tests, 100µg/L.

Fifty individuals (2.5%), all adults, had arsenic urine values exceeding the 100µg/L action threshold. Most individuals (97.5%) had values less than 100µg/L, including 28.9% that were undetectable.

The high number of individuals with detectable levels of arsenic likely reflects naturally occurring arsenic found in some common foods, particularly fish.

Of the individuals exceeding the arsenic action threshold, twenty have been interviewed. Among those interviewed, ingestion of seafood was the source identified for 18 (90%). For the other two, no sources such as fish, work, drinking water or herbal medications were identified. The levels attributed to seafood were presumably organic arsenic, which does not have a toxic effect.

Arsenic Blood (4,216 individuals tested)

Table 13. Age mean, median, and range of individual Michigan residents with blood arsenic tests in 2008 (n= 4,208*).

Statistic	Years
Mean	51.6
Median	51.8
Range	0.8 – 99.8

*8 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 2008 (n=4,189).

Sex	N(%)
Male	2,297 (54.8)
Female	1,892 (45.2)
Total	4,189 (100.0)

*Gender was missing/unknown in 27 (0.7%) of the total blood arsenic reports

Table 15. Mean, median, and range of blood arsenic tests in 2008 of individual Michigan residents (n=4,216).

Statistic	µg/L
Mean	2.4
Median	0.0
Range	0.0 – 385.7

Table 16. Distribution of individual Michigan residents' blood arsenic results (n=4,216).

Distribution Categories	n(%)
Above Action Threshold	4 (0.1)
Normal	2,007 (47.6)
Non-Detect	2,205 (52.3)
Total	4,216 (100.0)

Summary of Results

The demographic statistics of individuals receiving blood arsenic tests shown (Tables 13 and 14) differed slightly from those of the urine arsenic results shown previously. The mean age of individuals with blood arsenic tests was 51.6 and there were fewer females tested than males (45.2% vs. 54.8%) where gender was known.

The mean result value was 2.4µg/L which once again was well below the established action threshold of 70µg/L.

Four individuals were reported to exceed the 70µg/L action threshold, while the remaining reported values were evenly split between less than 70µg/L and non-detect (Table 16). No children were above the action threshold. One of the four individuals has been interviewed, and ingestion of seafood was identified as the source.

Cadmium Urine (408 individuals tested)

Table 17. Age mean, median, and range of individual Michigan residents with urine cadmium tests in 2008 (n=407*).

Statistic	**Years**
Mean	50.7
Median	51.7
Range	6.3 – 83.0

*1 individual receiving tests was 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 2008 (n=390).

Sex	**n**	**(%)**
Male	246	(63.1)
Female	144	(36.9)
Total	390	(100.0)

*Gender was missing/unknown in 18 (4.4%) of the total urine cadmium reports

Table 19. Specimen type submitted for urine cadmium tests of Michigan residents in 2008 (n=408).

Test Type	**n**	**(%)**
Random Urine	333	(81.6)
24 Hour Urine	75	(18.4)
Total	408	(100.0)

Table 20. Mean, median, and range of urine cadmium tests in 2008 of individual Michigan residents (n=408).

Statistic	**Value***
Mean	0.6
Median	0.0
Range	0.0 – 9.5

*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=408).

Distribution Categories	**n**	**(%)**
Above Action Threshold	27	(6.7)
Normal	174	(42.6)
Non-Detect	207	(50.7)
Total	408	(100.0)

Summary of Results

The mean age of individuals receiving urine cadmium tests was 50.7 years, and where gender was indicated, 63.1% were male and 36.9% female.

The mean result value for all urine tests (µg/L, µg/24 hours, µg/specimen, and µg/g creatinine) was 0.6.

Twenty-seven individuals, all adults, exceeded the action threshold for cadmium in urine. Twenty-three individuals had urine cadmium levels exceeding the 2µg/L action threshold and four individuals were reported with urine cadmium creatinine exceeding 3µg/g creatinine.

Among the 27 adults above the action level, five have been interviewed. The source of cadmium identified was work exposure in four individuals (14.8%), and an unknown non work source for the fifth individual.

Two work places with possible cadmium exposure were identified. One had a cadmium plating department. Michigan OSHA conducted an inspection of the facility. Six air samples for cadmium were taken. One was above the permissible exposure level (PEL) and another two were above the action level. The employer received citations as follows: One serious citation (did not provide respirators, did not require washing after exposure to cadmium, did not notify employees of urine or blood cadmium results, and exceeded the PEL), one repeat serious citation (no training program for employees exposed to cadmium, previously exceeded PEL, did not institute engineering or work practice controls, and did not collect or dispose of cadmium waste in sealed containers) and one other citation (did not record on the OSHA log employees with elevated cadmium levels who had restricted work days, did not inform individuals who laundered work clothes of the potential harmful effects of cadmium, did not include testing for Beta-2 microglobulin, air monitoring by company contained inadequate documentation and air testing not performed every six months).

The second facility was an aluminum foundry. No source of cadmium exposure was identified in this facility.

Cadmium Blood (1,887 individuals tested)

Table 22. Age mean, median, and range of individual Michigan residents with blood cadmium tests in 2008 (n=1,884*).

Statistic	**Years**
Mean	49.6
Median	49.4
Range	0.4 – 99.5

*3 individuals 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 2008 (n=1,884).

Sex	**n**	**(%)**
Male	1,127	(59.8)
Female	757	(40.2)
Total	1,884	(100.0)

*Gender was missing/unknown in 3 (0.1%) of the total blood cadmium reports.

Table 24. Mean, median, and range of blood cadmium tests in 2008 of individual Michigan residents (n=1,887).

Statistic	**µg/L**
Mean	0.5
Median	0.3
Range	0.0 – 13.7

Table 25. Distribution of individual Michigan residents' blood cadmium results (n=1,887).

Distribution Categories	**n**	**(%)**
Above Action Threshold	8	(0.4)
Normal	1,271	(67.4)
Non-Detect	608	(32.2)
Total	1,887	(100.0)

Summary of Results

The demographics of individuals receiving blood cadmium tests were similar to those that received urine cadmium tests. The mean age was 49.6 (Table 22) and when gender was reported, 59.8% were male and 40.2% were female (Table 23). Three individuals had no gender information reported.

The mean blood cadmium level was 0.5µg/L, one tenth of the action threshold (5µg/L).

The distribution of blood cadmium results shows seven adults exceeded the action threshold, and over 99% with levels below the action threshold, including 32% below the laboratories' level of detection.

One child under the age of 16 reported a blood level exceeding 5.0µg/L. Four of the seven adults have been interviewed. The sources of cadmium identified were smoking cigarettes in three individuals (57.1%), and work exposure in one individual (14.3%).

Mercury Urine (1,425 individuals tested)

Table 26. Age mean, median, and range of individual Michigan residents with urine mercury tests in 2008 (n=1,424*).

Statistic	Years
Mean	53.1
Median	52.8
Range	0.3 – 93.1

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

Table 27. Gender distribution, when gender is reported*, of individual Michigan residents with urine mercury tests in 2008 (n=1,402).

Sex	n	(%)
Male	792	(56.5)
Female	610	(43.5)
Total	1,402	(100.0)

*Gender was missing/unknown in 23 (1.6%) of the total urine mercury reports

Table 28. Specimen type submitted for urine mercury tests of Michigan residents in 2008 (n=1,425).

Test Type	n	(%)
Random Urine	1,199	(84.1)
24 Hour Urine	226	(15.9)
Total	1,425	(100.0)

Table 29. Mean, median, and range of urine mercury tests in 2008 of individual Michigan residents (n=1,425).

Statistic	Value*
Mean	0.4
Median	0.0
Range	0.0 – 21.0

*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=1,425).

Distribution Categories	n	(%)
Above Action Threshold	2	(0.1)
Normal	389	(27.4)
Non-Detect	1,034	(72.5)
Total	1,425	(100.0)

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

Level	n	(%)
>10	0	(0.0)
10 and under	16	(100.0)
Total	16	(100.0)

Summary of Results

The mean age of individuals receiving urine mercury tests was 53.1 years (Table 26). Where gender was known, more tests were performed on men (56.5%) than on women (43.5%), (Table 27). Gender was missing for 23 (1.6%) of the test reports.

Most of the results (84.1%) came from random urine tests.

The mean result value was 0.4 for tests measured in µg/L, µg/24 hours, µg/specimen, and µg/g creatinine.

The distribution of results show that only two individuals' urine mercury levels exceed the action threshold while the majority of the remaining values were non-detectable

Neither of the two values exceeding the action threshold was reported in an individual under the age of 16. Interviews are being attempted for both of these individuals..

Mercury Blood (4,068 individuals tested)

Table 32. Age mean, median and range of individual Michigan residents with blood mercury tests in 2008 (N=4,067)*.

Statistic	**Years**
Mean	51.6
Median	52.2
Range	0.8 – 99.5

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

Table 33. Gender distribution, when gender is reported, of individual Michigan residents with blood mercury tests in 2008 (n=4,048)*.

Sex	**n**	**(%)**
Male	2,174	(53.7)
Female	1,874	(46.3)
Total	4,048	(100.0)

*Gender was missing/unknown in 20 (0.5%) of the total blood mercury reports.

Table 34. Mean, median, and range of blood mercury tests in 2008 of Michigan residents (n=4,068).

Statistic	**Value***
Mean	1.2
Median	0.0
Range	0.0 – 55.5

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

Table 35. Distribution of individual Michigan residents' blood mercury results (n=4,068).

Distribution Categories	**n**	**(%)**
Above Action Threshold	30	(0.7)
Normal	1,917	(47.1)
Non-Detect	2,121	(52.1)
Total	4,068	(100.0)

Table 36. Number of individual Michigan residents <16 years of age with blood mercury levels > 10 µg/24 Hours, µg/L, µg/specimen or µg/g creatinine (n=121).

Level	**n**	**(%)**
≥10	1	(0.8)
Less than 10	120	(99.2)
Total	121	(100.0)

Table 37. Number of individual Michigan residents with blood mercury levels ≥30 µg/L (n= 4,068).

Level	**n**	**(%)**
≥30	6	(0.1)
Less than 30	4,062	(99.9)
Total	4,068	(100.0)

Summary of Results

The mean age of individuals receiving blood mercury tests (51.6 years) was lower than those receiving urine mercury tests (53.1 years).

For those individuals where gender was indicated, 53.7% were male and 46.3% were female. Twenty individuals (0.5%) were missing gender information.

The mean result value was 1.2µg/L

In the distribution of result values, 30 individuals exceed the action threshold (0.7%), including one child, while 1,917 (47.1%) had measurable levels below the action threshold and 2,121 (52.1%) had results below the level of laboratory detection.

Six individuals exceeded the Environmental Protection Agency's (EPA) level of concern, ≥30µg/L. This level was indicated as a level of interest to the EPA, via personal communication with Maureen O'Neill[4].

Thirteen adults have been interviewed to date. Among them, the source of mercury identified was seafood ingestion in nine individuals (69.2%), work exposure in one (7.7%). For the other three (23%), no sources were identified.

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

Follow-up Activities in 2008

In total, 123 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 below (Table 38). Two children exceeded the established action threshold for follow-up at the time of this report.

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	50	4	27	7	2	29	119
< 16	0	0	0	1	0	1	2
Total	50	4	27	8	2	30	121

Follow-up interviews have been conducted with 43 of the 123 individuals with values exceeding the action threshold. Listed below are the sources of exposure when identified for the 43 individuals interviewed (Table 39). Results for six interviews reported an unknown source of exposure.

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 naturally occurring arsenic in wells.

Table 39. Number of Adults exceeding action threshold where source of exposure has been identified via patient interview, Michigan 2008.

	Test and Specimen Type						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
Seafood	18	1	0	0	0	9	28
Work-Related	0	0	4	1	0	1	6
Cigarette Smoking	0	0	0	3	0	0	3
Unknown	2	0	1	0	0	3	6
Total	20	1	6	4	0	13	43

Summary

The volume of reports and the continued high percentage of non elevated values have raised questions about the indication for ordering the tests. We analyzed 2007 and 2008 data to assess the number of individuals for whom multiple types of testing was performed for metals as compared to testing for only a single metal. About 26.0% of people had all three heavy metals checked and another 47.3% had two heavy metals checked in 2008. It is likely in these individuals that that the health care provider ordered the metal testing without taking an exposure history since taking such a history would indicate it is generally unusual other than for some work places for a history to suggest exposure to more than a single heavy metal. 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 such a survey will be to develop a targeted education campaign for healthcare providers to assist them in determining the indications when a single test versus ordering two or more tests would be clinically useful. Finally, we will also assess if health care providers might need educational material to help with the interpretation of the laboratory results.

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Because the organic form of arsenic in fish does not have adverse health effects on humans (no public health follow up is indicated), we set an action threshold of 50µg/L in 2007 as compared to 35µg/L in 2006. Again in 2008, the action threshold levels were raised for arsenic urine specimens to 100µg/L. The summaries below reflect the number of individuals above 2006 arsenic urine standards (35µg/L, Table 40) and the number above current arsenic urine standards (100µg/L) for the entire three years the heavy metal registry has been in existence (Table 41)

Table 40. For 2006-2008, number of individuals by age, exceeding 2006 action threshold levels 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	478	1	99	35	9	100	722
< 16	8	0	0	2	1	4	15
Total	486	1	99	37	10	104	737

Table 41. For 2006-2008, number of individuals by age, exceeding current action threshold levels 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	207	1	99	35	9	100	451
< 16	0	0	0	2	1	4	7
Total	207	1	99	37	10	104	458

To date, 442 individuals have been interviewed. Table 42 summarizes the sources of the metals for the 442 interview results. Individuals who were interviewed but no source could be identified were classified as having “unknown” source of exposure. Ingestion of seafood was the predominant source of elevated arsenic levels, 191(43.2%) of all individuals reported to the registry. On the other hand mercury in fish does have adverse human health effects, particularly to fetuses and newborn. Educational material was provided to individuals with elevated mercury from seafood ingestion. We also provided educational material to the relatively few individuals where well water was the suspected source, since well water contains arsenic in the inorganic toxic form.

Table 42. Number of Adults exceeding action threshold where source of exposure has been identified via patient interview, Michigan 2006, 2007, and 2008.

	Test and Specimen Type						
Source of Exposure	AsU	AsB	CdU	CdB	HgU	HgB	Total
Seafood	191	1	0	0	2	56	250
Work-Related	6	0	15	6	1	8	36
Well Water	10	0	0	0	0	0	10
Cigarette Smoking	0	0	6	12	0	0	18
Herbal Supplement	0	0	0	0	0	1	1
Chelation	0	0	0	1	0	0	1
Medicinals	1	0	0	0	0	1	2
Unknown	81	0	25	5	0	13	124
Total	289	1	46	24	3	79	442

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