Heavy Metals Surveillance in Michigan: Fourth Annual Report (January 2009 – December 2009)

MICHIGAN STATE
UNIVERSITY

Department of Medicine
117 West Fee Hall
East Lansing, MI 48824

and

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

Michigan Department of Community Health
MDCH

Jennifer M. Granholm, Governor
Janet Olszewski, Director

June 2010

Heavy Metals Surveillance in Michigan: Fourth Annual Report (January 2009 – December 2009)

A Joint Report of

Michigan State University

and

Michigan Department of Community Health

Prepared by:
Joanna Kica, MPA
Mary Jo Reilly, MS
Amy Krizek, BS
Martha Stanbury, MSPH
Kenneth Rosenman, MD

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

Author affiliations: Joanna Kica, Mary Jo Reilly, 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, P.O. Box 30195, Lansing MI 48909.

This publication was partially supported by grant numbers U90/CCU517018 and U60/OH008466 from the Centers for Disease Control and Prevention (CDC). Its contents are solely the responsibility of the authors and do not represent the official views of CDC.

Table of Contents:

Executive Summary – Michigan Heavy Metals Surveillance Project 2009 Annual Report

- In September 2005, Michigan Department of Community Health (MDCH) promulgated rules requiring laboratories to report clinical laboratory results of all arsenic (As), cadmium (Cd), and mercury (Hg) tests in blood and urine.

- The reporting requirement was established so that MDCH could improve 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 2009 annual report spans 01/01/2009 through 12/31/2009.

- In 2009, 15,982 total reports were received on 6,857 individuals during the reporting period. These numbers are similar to those from 2008.

- In 2009, 101 (1.47%) individuals had a result that exceeded one of the established action thresholds (97 adults and 4 children under the age of 16).

- In 2009, one workplace investigation was initiated by Michigan Occupational Safety and Health Administration (MIOSHA), for elevated mercury levels in one worker. Screening samples for mercury vapor were taken at the facility but no mercury vapors were detected. Recommendations were issued regarding incorporating the recognition and health hazards of mercury vapor into the firm's existing practices and procedures. MIOSHA's inspection of another workplace for elevated blood lead level, found detectable levels of not only lead but also cadmium through personal air monitoring results. However, the air contaminant levels were within the Assigned Protect Factor (APF) of the respiratory protection used, and therefore no citations were issued for the company.

- 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 needed 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 2010.

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 (see Appendix 1). Like other public health surveillance systems, the system built on this reporting requirement includes a sufficient collection of information about tested individuals and their health care providers to conduct follow-up to identify the source of exposure, which then if necessary triggers public health actions to mitigate exposures to others. The reporting requirement was established so that MDCH could improve 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 individuals in Michigan in 2009. 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 (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. Among all tests collected, almost eighty-six percent were submitted electronically while fourteen percent were submitted in a paper form.

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 (Table 1) are based on the following:

[1] ATSDR, Division of Toxicology and Environmental Medicine ToxFAQs, Arsenic, August 2007: http://www.atsdr.cdc.gov/tfacts2.pdf
ATSDR, Division of Toxicology and Environmental Medicine ToxFAQs, Cadmium, September 2008: 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

Table 1. Action thresholds identified for follow-up by test and specimen type, 2009.

Test Type	Specimen Type	Elevated
Arsenic	Blood	>70 µg/L
	Urine – adults	≥100 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 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 Governmental 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 than 100µg/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 Governmental 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*[3].

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 interview 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

MDCH received 15,982 total lab result reports into the Heavy Metals Surveillance Project on 6,857 individuals who were tested between January 1, 2009 and December 31, 2009. These reports were submitted from the twelve 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 2009 (n=15,981)*.

Laboratory Name	n	%
ARUP Laboratories	2,763	17.3
Lab Corp of America	2,231	14.0
Mayo Medical Laboratories	6,359	39.8
Nichols Institute	1	0.0
NMS Labs	2	0.0
Quest Diagnostics, Inc. Auburn Hills	1,789	11.2
Quest Diagnostics, Inc. Wood Dale	3	0.0
South Bend Medical Foundation	105	0.7
Specialty Laboratories, Inc.	2,694	16.8
Spectrum Health Toxicology Lab	18	0.1
Sturgis Hospital	14	0.1
Warde Medical Laboratory	2	0.0
Total	**15,981**	100.0

*The name of one laboratory was unknown.

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 (56.1%) than females (43.9%).

Table 3. Distribution of gender, when reported*, in 2009 (n=6,846).

Sex	n	%
Male	3,841	56.1
Female	3,005	43.9
Total	6,846	100.0

*Gender was missing for 11 (0.2 %) of the total number of individuals (n=6,857).

Race and ethnicity information were largely unreported. The available race information is in Table 4; 74.0% 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 2009 (n=1,783).

Race	n	%
White	1,675	94.0
Black	89	5.0
Asian	2	0.1
Native American	2	0.1
Other	15	0.8
Total	1,783	100.0

*Race was missing for 5,074 (74.0%) of the total number of individuals (n=6,857).

The total number of 15,982 reports received in the 2009 reporting year represent six unique test (arsenic, cadmium, mercury) and specimen type (blood and urine) combinations. Table 5 and Graph 5

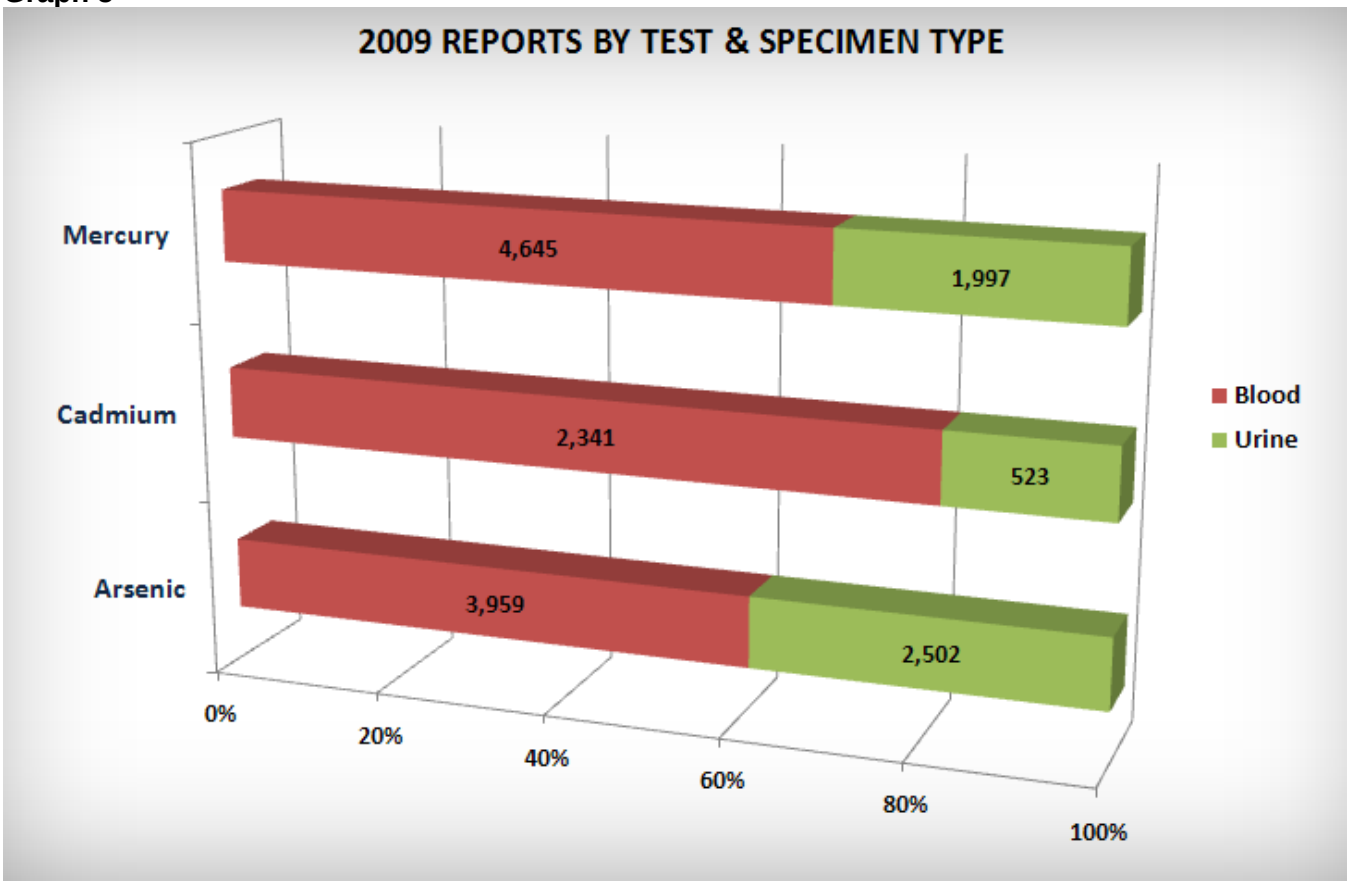
show how many reports were received for each of these unique combinations. The following sections discuss each of these individual combinations. However, since a single person may receive repeated tests throughout the reporting year, each subset of test and specimen type was de-duplicated such that each individual may contribute only a single report per subset. First, the records were matched on date of birth, last name, and first name. Next, 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 2009 reporting year (n=15,967)*.

	Specimen Type		
Test Type	Blood	Urine	Total
Arsenic	3,959	2,502	6,461
Cadmium	2,341	523	2,864
Mercury	4,645	1,997	6,642
Total	10,945	5,022	15,967

*Test type and/or specimen type was missing for 15 (0.1%) of the total number of reports (n=15,982).

Graph 5



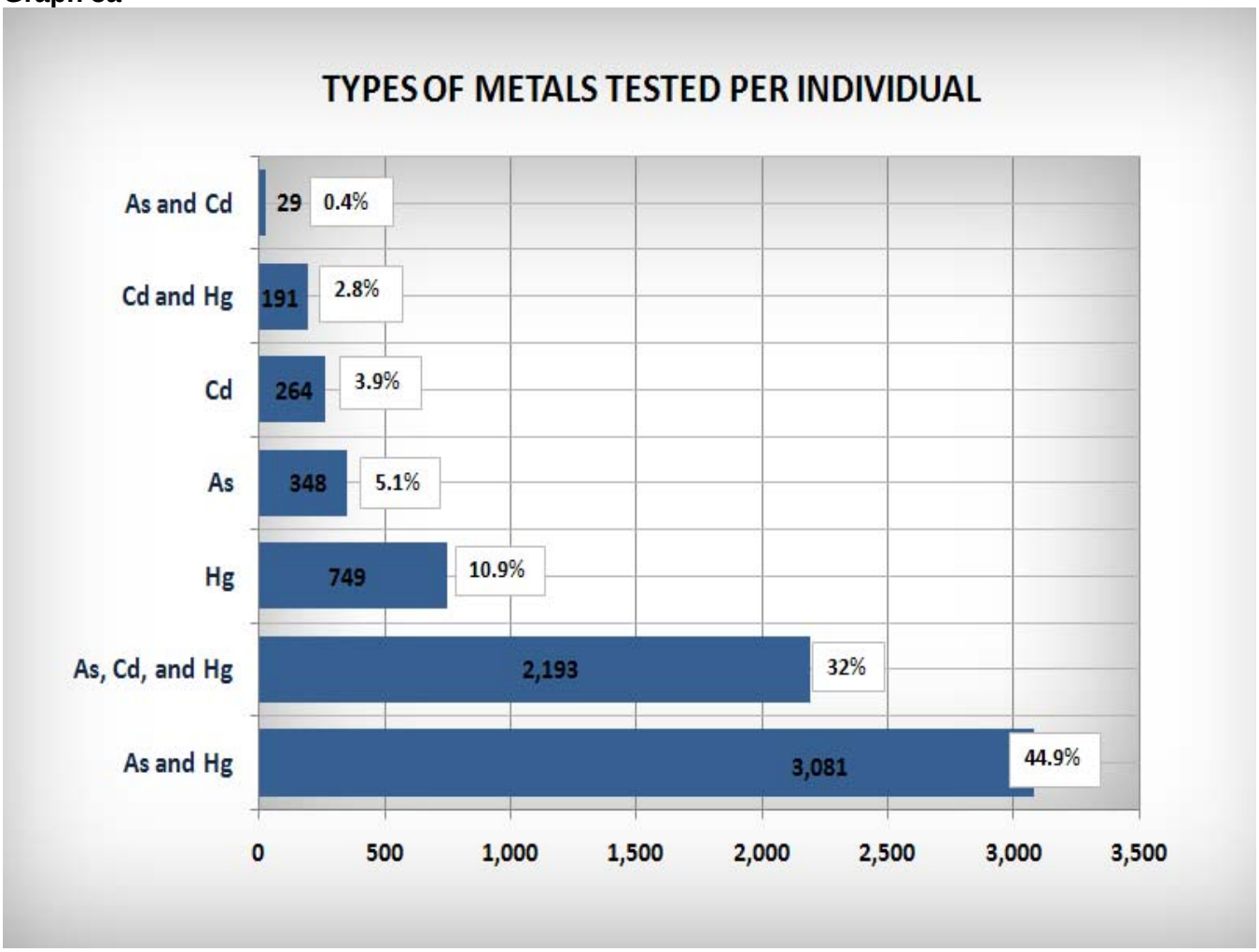
The data in Table 5a and Graph 5a show that 32.0% of individuals had testing for all three metals, typically ordered as a heavy metal panel while most individuals (44.9%) had testing done for both arsenic and mercury.

Table 5a. Types of metal(s) tested per individual (n=6,855)*.

Metals	n	%
As	348	5.1
Cd	264	3.9
Hg	749	10.9
As and Cd	29	0.4
As and Hg	3,081	44.9
Cd and Hg	191	2.8
As, Cd, and Hg	2,193	32.0
Total	6,585	100.0

*Test type was missing for 2 individuals of the total number of individuals (n=6,857).

Graph 5a

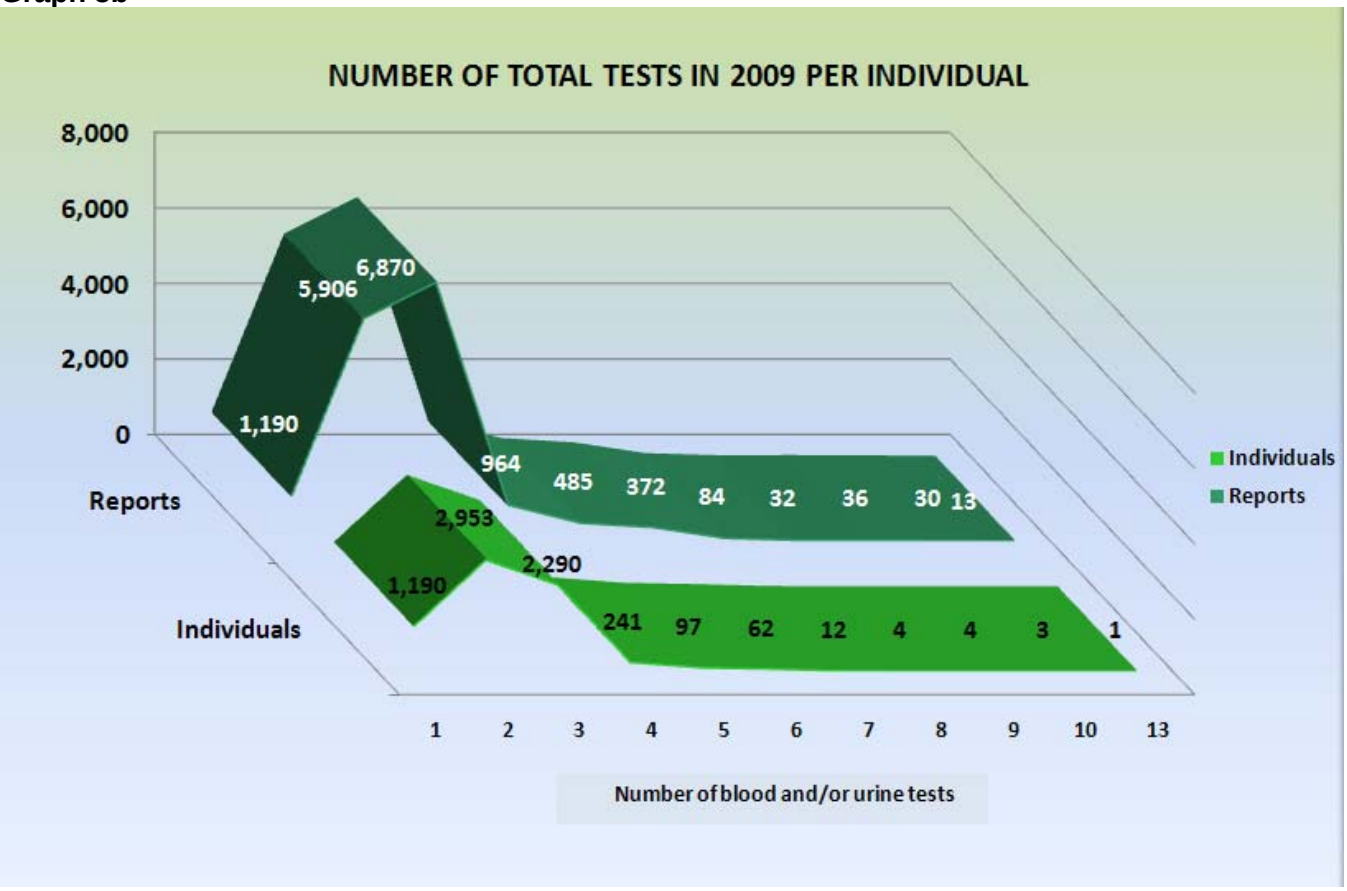


Most individuals (43.1%) who were tested had two blood and/or urine measurements performed (Table 5b and Graph 5b).

Table 5b. Number of total tests (n=15,982) in 2009 per individual (n=6,857).

Number of blood and/or urine tests	Individuals	%	Reports
1	1,190	17.3	1,190
2	2,953	43.1	5,906
3	2,290	33.4	6,870
4	241	3.5	964
5	97	1.4	485
6	62	0.9	372
7	12	0.2	84
8	4	0.1	32
9	4	0.1	36
10	3	0.0	30
13	1	0.0	13
Total	6,857	100.0	15,982

Graph 5b



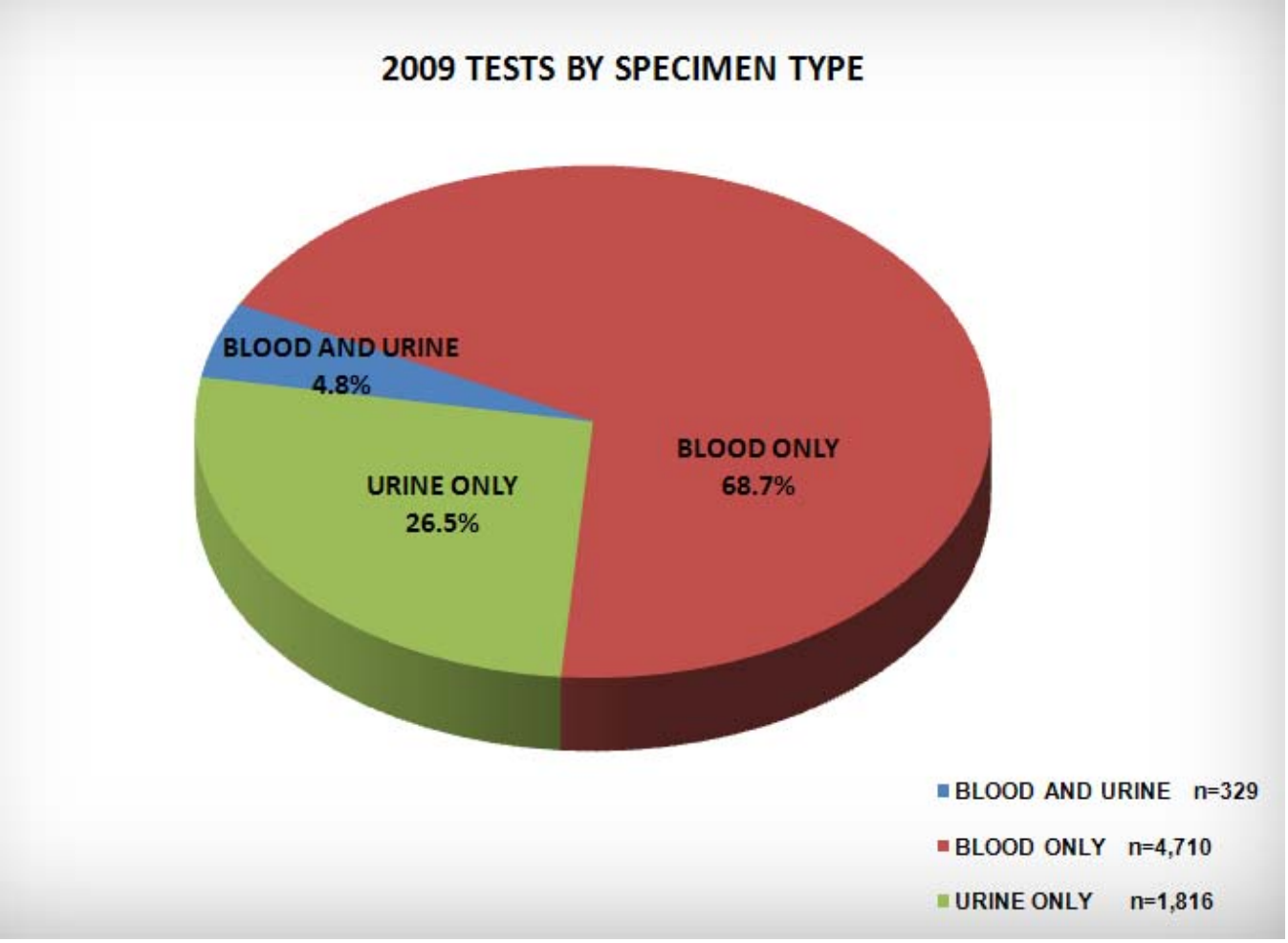
Among the individuals receiving tests, the most common specimen taken was blood, over two-thirds (68.7%) of all tests (Table 5c and Graph 5c).

Table 5c. Tests by specimen type per individual in 2009 (n=6,855)*.

Tests	n	%
Blood and Urine	329	4.8
Blood only	4,710	68.7
Urine only	1,816	26.5
Total	6,855	100.0

*Specimen type was missing for 2 individuals of the total number of individuals (n=6,857).

Graph 5c



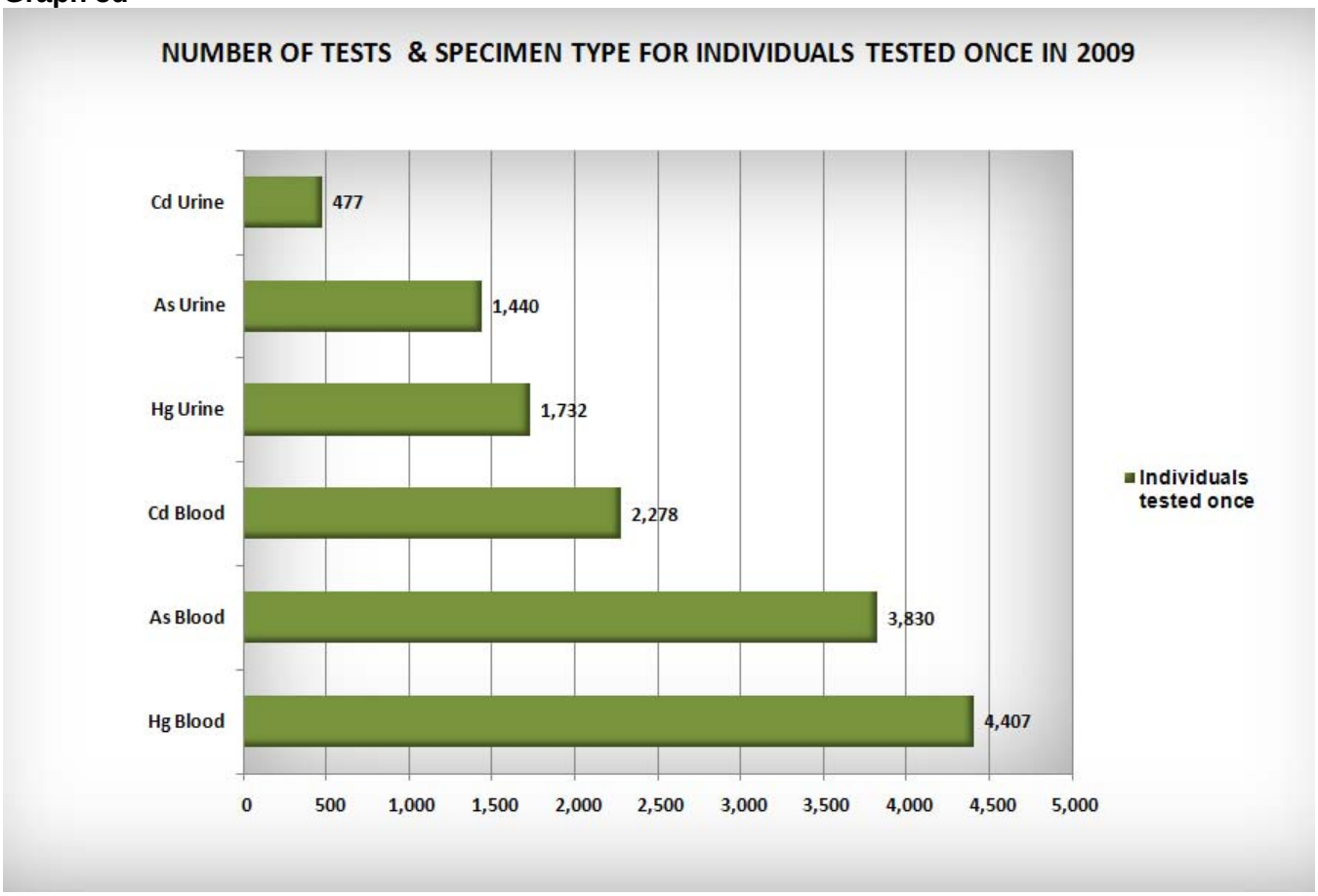
For individuals who were only tested once, the most common test and specimen combination was mercury blood (4,407). Cadmium urine tests were the least common type of testing performed among individuals in 2009 (477), (Table 5d and Graph 5d).

Table 5d. Number of heavy metal tests in 2009 per individual (n=15,967)*.

Test and Specimen Type	Individuals tested once	Tested two times	Tested three times	Tested four times	Tested five times	Tested six times	Tested seven times	Total Tests
As Blood	3,830	63	1	0	0	0	0	3,959
As Urine	1,440	341	63	34	6	3	1	2,502
Cd Blood	2,278	30	1	0	0	0	0	2,341
Cd Urine	477	17	2	0	0	1	0	523
Hg Blood	4,407	100	8	2	0	1	0	4,645
Hg Urine	1,732	116	11	0	0	0	0	1,997
Total	14,164	667	86	36	6	5	1	15,967

*Test or specimen type was missing for 15 tests of the total number of heavy metal tests (n=15,982).

Graph 5d



Arsenic Urine
(2,502 tests performed on 1,888 individuals)

Table 6. Age mean, median and range of individuals tested in Michigan in 2009 for urine arsenic (n=1,850)*.

Statistic	Years
Mean	51.1
Median	52.0
Range	<1.0 - 97.0

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

Table 7. Gender distribution, when gender was reported*, of individuals tested in Michigan in 2009 for urine arsenic (n=1,886).

Sex	n	%
Male	1,128	59.8
Female	758	40.2
Total	1,886	100.0

*Gender was missing in 2 (0.1%) of the total individuals tested for urine arsenic (n=1,888).

Table 8. Specimen type submitted for urine arsenic tests of individuals tested in Michigan in 2009 (n=2,502).

Test Type	n	%
Random Urine	2,155	86.1
24 Hour Urine	347	13.9
Total	2,502	100.0

Table 9. Mean, median, and range of urine arsenic tests of individuals tested in Michigan in 2009 (n=1,524)*.

Statistic	Value**
Mean	25.6
Median	16.0
Range	0.1 – 1320.0

*924 urine arsenic tests were non-detect and 54 urine arsenic tests had sample units that were reported incorrectly by one laboratory, therefore none of those 978 (39.1%) urine arsenic tests of the total urine arsenic tests (n=2,502) were included in the analysis.
**Includes results measured in µg/L, µg/24 Hours, and µg/specimen.

Table 10. Distribution of urine arsenic tests' results among individuals tested in Michigan in 2009 (n=1,796)*.

Distribution Categories	n	%
Above Action Threshold	36	2.0
Normal	1,760	98.0
Total	1,796	100.0

*Of 92 (4.9%) individuals of the total individuals tested (n=1,888), 54 received tests which sample units were reported incorrectly, and 38 were missing DOB or age, and were excluded from the analysis. 38 individuals who were missing DOB or age are excluded from the analysis in Table 11 and Table 12.

Table 11. Number of individuals ≥16 years of age tested in Michigan in 2009 with urine arsenic levels ≥100 µg/L, µg/24 Hours, and µg/specimen (n=1,734)*.

Level	n	%
≥ 100	34	2.0
< 100	1,700	98.0
Total	1,734	100.0

*50 (2.8%) adults of the total adults tested (n=1,784) received urine arsenic tests which sample units were reported incorrectly by one laboratory and were excluded from the analysis.

Table 12. Number of individuals <16 years of age tested in Michigan in 2009 with urine arsenic levels ≥50 µg/L, µg/24 Hours, and µg/specimen (n=62)*.

Level	n	%
≥50	2	3.2
< 50	60	96.8
Total	62	100.0

*4 (6.1%) individuals <16 years of age of the total individuals tested (n=66) received urine arsenic tests which sample units were reported incorrectly by one laboratory and were excluded from the analysis.

Summary of Results

The mean age of individuals with urine arsenic tests was 51.1 years (Table 6). When gender was given, 59.8% of the individuals were males and 40.2% were females (Table 7).

Specimens submitted were 86.1% random urine, and 13.9% were 24-hour urine collections (Table 8).

The average urine arsenic result was 25.6µg/L (Table 9). The mean result value includes results for all test types that are measured in µg/L, µg/24 hours, and µg/specimen. This average value was well below the action threshold for adult's arsenic urine tests which is equal or greater than 100µg/L as well as children's arsenic urine tests which is equal or greater than 50µg/L. The analysis does not include 54 tests that were received from one laboratory because sample units were reported incorrectly for evaluation.

Thirty-four adults (2.0%) had arsenic urine values exceeding the 100µg/L action threshold. Most individuals (98.0%) had values less than 100µg/L, including 26.4% that were undetectable (Table 11). Of the all children tested, two children (3.2%) had arsenic result values exceeding the 50µg/L action threshold (Table 12).

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

Of the thirty-four adults exceeding the arsenic action threshold, nine were interviewed. Among those interviewed, ingestion of seafood was the source identified for four and a suicide attempt for one individual. For the other four adults, work and well water were definitely not the source. The presumed source was food or herbal medication. The levels attributed to seafood were presumably organic arsenic, which does not have a toxic effect. Well water was identified as a source of exposure for one child who was above the action threshold. Interview of the other child is pending.

Arsenic Blood
(3,959 tests performed on 3,894 individuals)

Table 13. Age mean, median and range of individuals tested in Michigan in 2009 for blood arsenic (n=3,893)*.

Statistic	Years
Mean	49.7
Median	51.0
Range	<1.0 - 97.0

*1 individual tested was missing DOB or age and was excluded from the analysis.

Table 14. Gender distribution, when gender was reported*, of individuals tested in Michigan in 2009 for blood arsenic (n=3,889).

Sex	n	%
Male	2,049	52.7
Female	1,840	47.3
Total	3,889	100.0

*Gender was missing in 5 (0.1%) of the total individuals tested for blood arsenic (n=3,894).

Table 15. Mean, median, and range of blood arsenic tests of individuals tested in Michigan in 2009 (n=1,642)*.

Statistic	µg/L
Mean	4.3
Median	3.0
Range	0.02 – 728.0

*2,317 (58.5%) blood arsenic tests of the total blood arsenic tests (n=3,959) were non-detect and were not included in the analysis.

Table 16. Distribution of blood arsenic tests' results among individuals tested in Michigan in 2009 (n=3,894).

Distribution Categories	n	%
Above Action Threshold	2	0.1
Normal	3,892	99.9
Total	3,894	100.0

Summary of Results

The mean age of individuals with blood arsenic tests was 49.7 years and there were fewer females tested than males (47.3% vs. 52.7%) where gender was known (Tables 13 and 14).

The mean result value was 4.3µg/L which was well below the established action threshold of 70µg/L (Table 15).

Two individuals were reported to exceed the 70µg/L action threshold (Table 16). No children were above the action threshold.

Cadmium Urine
(523 tests performed on 497 individuals)

Table 17. Age mean, median and range of individuals tested in Michigan in 2009 for urine cadmium (n=495)*.

Statistic	Years
Mean	52.3
Median	53.0
Range	1.0 - 94.0

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

Table 18. Gender distribution, when gender was reported*, of individuals tested in Michigan in 2009 for urine cadmium (n=496).

Sex	n	%
Male	301	60.7
Female	195	39.3
Total*	496	100.0

*Gender was missing in 1 (0.2%) of the total individuals tested for urine cadmium (n=497).

Table 19. Specimen type submitted for urine cadmium tests of individuals tested in Michigan in 2009 (n=523).

Test Type	n	%
Random Urine	432	82.6
24 Hour Urine	91	17.4
Total	523	100.0

Table 20a. Mean, median, and range of urine cadmium tests measured in µg/L, µg/24 Hours, and µg/specimen of individuals tested in Michigan in 2009 (n=345)*.

Statistic	Value
Mean	0.9
Median	0.5
Range	0.1 - 18.80

*178 (34.0%) urine cadmium tests of the total urine cadmium tests (n=523) were either non-detect or measured in µg/g creatinine, and were not included in the analysis.

Table 20b. Mean, median, and range of urine cadmium tests measured in µg/g creatinine of individuals tested in Michigan in 2009 (n=21)*.

Statistic	Value
Mean	1.3
Median	0.7
Range	0.1 - 7.1

*502 (96.0%) urine cadmium tests of the total urine cadmium tests (n=523) were either non-detect or measured in µg/L, µg/24 Hours, and µg/specimen, and were not included in the analysis.

Table 21a. Distribution of urine cadmium tests' results measured in µg/L, µg/24 Hours, and µg/specimen among individuals tested in Michigan in 2009 (n=486).

Distribution Categories	n	%
Above Action Threshold	17	3.5
Normal	469	96.5
Total	486	100.0

Table 21b. Distribution of urine cadmium tests' results measured in µg/g creatinine among individuals tested in Michigan in 2009 (n=31).

Distribution Categories	n	%
Above Action Threshold	2	6.5
Normal	29	93.5
Total	31	100.0

Summary of Results

The mean age of individuals receiving urine cadmium tests was 52.3 years (Table 17), and where gender was indicated, 60.7% were male and 39.3% female (Table 18).

The mean result value for all urine tests measured in µg/L, µg/24 hours, and µg/specimen was 0.9 (Table 20a), while measured in µg/g creatinine was 1.3 (Table 20b).

Nineteen individuals, all adults, exceeded the action threshold for cadmium in urine. Seventeen individuals had urine cadmium levels exceeding the 2µg/L action threshold (Table 21a) and two individuals were reported with urine cadmium creatinine exceeding 3µg/g creatinine (Table 21b).

Among the nineteen adults above the action level, three were interviewed. The source of cadmium identified was cigarette smoke exposure in one individual, and an unknown, presumably food source for the other two individuals.

Cadmium Blood
(2,341 tests performed on 2,309 individuals)

Table 22. Age mean, median and range of individuals tested in Michigan in 2009 for blood cadmium (n=2,308)*.

Statistic	Years
Mean	48.0
Median	49.0
Range	<1.0 - 97.0

*1 individual tested was missing DOB or age and was excluded from the analysis.

Table 23. Gender distribution, of individuals tested in Michigan in 2009 for blood cadmium (n=2,309).

Sex	n	%
Male	1,402	60.7
Female	907	39.3
Total	2,309	100.0

Table 24. Mean, median, and range of blood cadmium tests of individuals tested in Michigan in 2009 (n=1,287)*.

Statistic	µg/L
Mean	0.7
Median	0.4
Range	0.2 – 53.0

*1,054 (45.0%) blood cadmium tests of the total blood cadmium tests (n=2,341) were non-detect and were not included in the analysis.

Table 25. Distribution of blood cadmium tests' results among individuals tested in Michigan in 2009 (n=2,309).

Distribution Categories	n	%
Above Action Threshold	4	0.2
Normal	2,305	99.8
Total	2,309	100.0

Summary of Results

The mean age of individuals receiving blood cadmium tests was 48.0 years (Table 22) and 60.7% were male and 39.3% were female (Table 23).

The mean blood cadmium level was 0.7µg/L.

The distribution of blood cadmium results shows four adults exceeded the action threshold, and over 99% with levels below the action threshold, including 44.7% below the laboratories' level of detection (Table 25).

No child under the age of 16 reported a blood level exceeding 5.0µg/L. One of the four adults was interviewed. The source of cadmium identified was smoking cigarettes.

Mercury Urine
(1,997 tests performed on 1,859 individuals)

Table 26. Age mean, median and range of individuals tested in Michigan in 2009 for urine mercury (n=1,820)*.

Statistic	Years
Mean	51.0
Median	52.0
Range	<1.0 - 97.0

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

Table 27. Gender distribution, when gender was reported*, of individuals tested in Michigan in 2009 for urine arsenic (n=1,856).

Sex	n	%
Male	1,121	60.4
Female	735	39.6
Total	1,856	100.0

*Gender was missing in 3 (0.2%) of the total individuals tested for urine mercury (n=1,859).

Table 28. Specimen type submitted for urine cadmium tests of individuals tested in Michigan in 2009 (n=1,997).

Test Type	n	%
Random Urine	1,694	84.8
24 Hour Urine	303	15.2
Total	1,997	100.0

Table 29a. Mean, median, and range of urine mercury tests measured in µg/L, µg/24 Hours, and µg/specimen of individuals tested in Michigan in 2009 (n=545)*.

Statistic	Value
Mean	1.3
Median	1.0
Range	0.01 - 15.0

*1,452 (72.7%) urine mercury tests of the total urine mercury tests (n=1,997) were either non-detect or measured in µg/g creatinine, and were not included in the analysis.

Table 29b. Mean, median, and range of urine mercury tests measured in µg/g creatinine of individuals tested in Michigan in 2009 (n=60)*.

Statistic	Value
Mean	1.2
Median	1.0
Range	1.0 - 3.0

*1,937 (97.0%) urine mercury tests of the total urine mercury tests (n=1,997) were either non-detect or measured in µg/L, µg/24 Hours, and µg/specimen, and were not included in the analysis.

Table 30a. Distribution of urine mercury tests' results measured in µg/L, µg/24 Hours, and µg/specimen among individuals tested in Michigan in 2009 (n=1,794).

Distribution Categories	n	%
Above Action Threshold	1	0.1
Normal	1,793	99.9
Total	1,794	100.0

Table 30b. Distribution of urine mercury tests' results measured in µg/g creatinine among individuals tested in Michigan in 2009 (n=101).

Distribution Categories	n	%
Above Action Threshold	0	0.0
Normal	101	100.0
Total	101	100.0

Table 31. Number of individuals <16 years of age tested in Michigan in 2009 with urine mercury levels >10 µg/L, µg/24 Hours, and µg/specimen (n=61).

Level	n	%
>10	1	1.6
≤10	60	98.4
Total	61	100.0

Summary of Results

The mean age of individuals receiving urine mercury tests was 51.0 years (Table 26). More tests were performed on men (60.4%) than on women (39.6%), (Table 27).

Most of the results (84.8%) came from random urine tests (Table 28).

The mean result value was 1.3 for tests measured in µg/L, µg/24 hours, and µg/specimen (Table 29a), and 1.2 for tests measured in µg/g creatinine (Table 29b).

The distribution of results show that only one individual under the age of 16 exceeded the action threshold of urine mercury level while the majority of the remaining values were normal (Table 31). Ingestion of seafood was the source identified for this individual.

Mercury Blood
(4,645 tests performed on 4,518 individuals)

Table 32. Age mean, median and range of individuals tested in Michigan in 2009 for blood mercury (n=4,516)*.

Statistic	Years
Mean	49.3
Median	51.0
Range	<1.0 - 97.0

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

Table 33. Gender distribution, when gender was reported*, of individuals tested in Michigan in 2009 for blood mercury (n=4,511).

Sex	n	%
Male	2,383	52.8
Female	2,128	47.2
Total	4,511	100.0

*Gender was missing in 7 (0.2%) of the total individuals tested for blood mercury (n=4,518).

Table 34. Mean, median, and range of blood mercury tests of individuals tested in Michigan in 2009 (n=1,936)*.

Statistic	µg/L
Mean	2.7
Median	2.0
Range	0.0 - 63.19

*2,709 (58.3%) blood mercury tests of the total blood mercury tests (n=4,645) were non-detect and were not included in the analysis.

Table 35. Distribution of blood mercury tests' results among individuals tested in Michigan in 2009 (n=4,512)*.

Distribution Categories	n	%
Above Action Threshold	39	0.9
Normal	4,477	99.1
Total	4,516	100.0

*2 individuals of the total individuals tested (n=4,518) had unknown blood mercury tests' results.

Table 36. Number of individuals <16 years of age tested in Michigan in 2009 with blood mercury levels >10 µg/L, µg/24 Hours, and µg/specimen (n=342).

Level	n	%
>10	1	0.3
≤10	341	99.7
Total	342	100.0

Table 37. Number of individuals tested in Michigan in 2009 with blood mercury levels ≥30 µg/L* (n=4,518).

Level	n	%
≥30	4	0.1
<30	4,514	99.9
Total	4,518	100.0

*****Environmental Protection Agency's level of concern.

Summary of Results

The mean age of individuals receiving blood mercury tests (49.3 years) was lower than those receiving urine mercury tests (51.0 years), (Table 32).

For those individuals where gender was indicated, 52.8% were male and 47.2% were female. Seven individuals (0.2%) were missing gender information (Table 33).

The mean result value was 2.7µg/L (Table 34).

In the distribution of result values, thirty-nine individuals exceeded the action threshold (0.9%), including one child, while 1,830 (40.5%) had measurable levels below the action threshold and 2,647 (58.6%) had results below the level of laboratory detection (Table 35).

Four 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].

Twenty-one adults and parents of one child, who exceeded the action threshold of blood mercury levels, have been interviewed to date. Among them, the source of mercury identified was seafood ingestion in nineteen individuals (86.4%). For the other three (13.6%), no sources were identified.

One workplace with possible mercury exposure was identified. Michigan OSHA, General Industry Safety and Health Division conducted an inspection of the facility. The inspection revealed that production torch cutting activities have decreased significantly from previous MIOSHA interventions. Screening samples for mercury vapor were taken, but none were detected. Although, no citations were issued, the inspection revealed many conditions, which may constitute a threat to the safety or health of the employees. MIOSHA made the following recommendation: "Incorporate the recognition and health hazards of mercury vapor into the firm's existing Employee Right-To-Know/Hazard Communication."

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

Follow-up Activities in 2009

In total, one hundred and one 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). Four 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.

Age	Test and Specimen Type						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
16 and over	34	2	19	4	0	38	97
< 16	2	0	0	0	1	1	4
Total	36	2	19	4	1	39	101

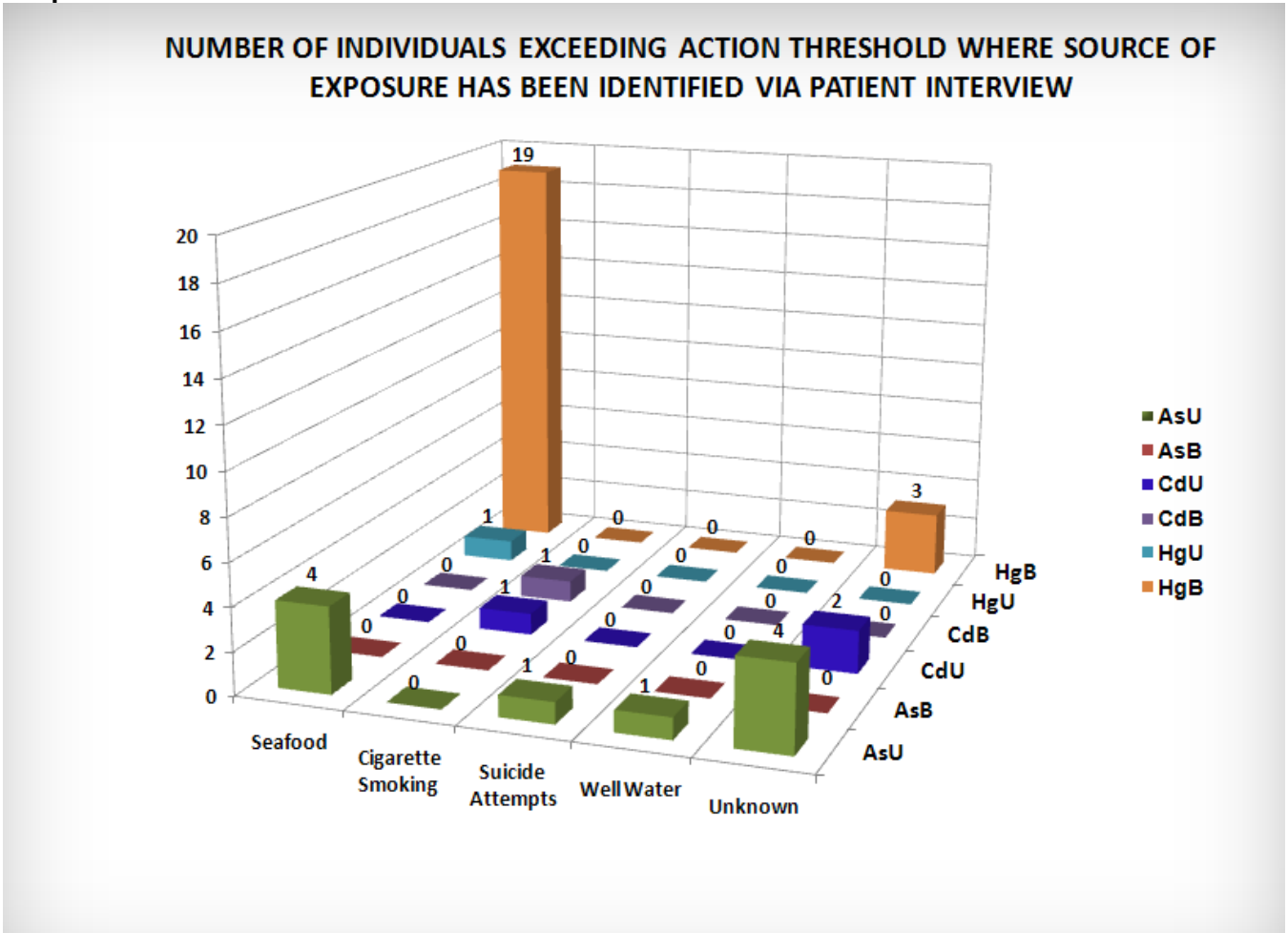
Follow-up interviews have been conducted with thirty-seven of the one hundred and one individuals with values exceeding the action threshold. Listed below are the sources of exposure when identified for the thirty-seven individuals interviewed (Table 39 and Graph 39). Results for nine interviews reported 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 individuals exceeding action threshold where source of exposure has been identified via patient interview, Michigan 2009.

Source of Exposure	Test and Specimen Type						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
Seafood	4	0	0	0	1	19	24
Cigarette Smoking	0	0	1	1	0	0	2
Suicide Attempt	1	0	0	0	0	0	1
Well Water	1	0	0	0	0	0	1
Unknown	4	0	2	0	0	3	9
Total	10	0	3	1	1	22	37

Graph 39



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 2009 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. Thirty-two percent of people had all three heavy metals checked and another forty-eight percent had two heavy metals checked in 2009. It is likely in these individuals 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 an exposure 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.

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. In 2008, the action threshold levels for adults were again raised for arsenic urine specimens to 100µg/L, while for the children the threshold remained at 50µg/L level. Follow up of elevated blood or

urine arsenic levels has not identified situations that warrant a public health intervention. Accordingly, interviews of individuals with elevated arsenic levels have been given a low priority.

The summaries below reflect the number of adults and children above threshold values since the Heavy Metals Registry was instituted in 2006. The current arsenic urine threshold values (100µg/L for adults - Table 40, and 50µg/L for children – Table 41) was used for all years and so the numbers of results above the action threshold in this table are smaller than the numbers with analogous tables in the previous annual reports for 2006-2008.

Table 40. Number of individuals ≥ 16 years of age, exceeding current action threshold levels and requiring follow up for each subset of test and specimen type, for 2006-2008 and 2009.

Year	Test and Specimen Type						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
2006-2008	207	1	99	35	9	100	451
2009	34	2	19	4	0	38	97
Total	241	3	118	39	9	138	548

Table 41. Number of individuals < 16 years of age, exceeding current action threshold levels and requiring follow up for each subset of test and specimen type, for 2006-2008 and 2009.

Year	Test and Specimen Type						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
2006-2008	0	0	0	2	1	4	7
2009	2	0	0	0	1	1	4
Total	2	0	0	2	2	5	13

To date, 479 individuals have been interviewed. Table 42 summarizes the sources of the metals for the 479 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, 274 (57.3%) of all individuals reported to the registry. On the other hand mercury in fish does have adverse human health effects, particularly to fetuses and newborns. 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 of their elevated arsenic level, since well water contains arsenic in the inorganic toxic form.

Table 42. Number of individuals exceeding action threshold where source of exposure has been identified via patient interview, Michigan 2006 - 2009.

Source of Exposure	**Test and Specimen Type**						
	AsU	AsB	CdU	CdB	HgU	HgB	Total
Seafood	195	1	0	0	3	75	274
Work-Related	6	0	15	6	1	8	36
Well Water	11	0	0	0	0	0	11
Cigarette Smoking	0	0	7	13	0	0	20
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
Suicide Attempt	1	0	0	0	0	0	1
Unknown	85	0	27	5	0	16	133
Total	299	1	49	25	4	101	479

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 affecting Michigan residents. The data will be used when indicated to conduct interventions to reduce exposures and potential adverse health effects to both the individuals with the elevated metal levels as well others who because of similar circumstances face similar risks.

2008 Annual Report Annotation

Quality control edits performed in preparation of this year's annual report found errors in last year's 2008 report published in May, 2009. The major error was that 1,586 laboratory reports were counted twice. Another 163 laboratory reports received as paper records were not included in the analyses of the individual metals and 30 laboratory reports that were included were for years prior to 2008. These errors do not change the conclusions in the executive summary of the 2008 report but do reduce the correct total number of reports for 2008 from over 17,000 to approximately 15,000.

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