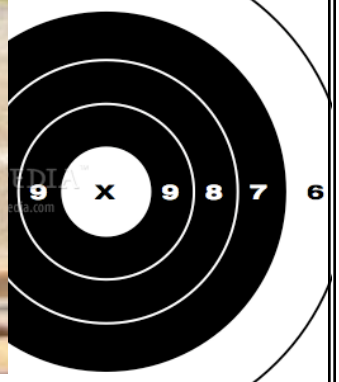
2015 - 2016 Report

Adult Blood Lead Epidemiology Surveillance (ABLES) Program

January 15, 2018



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Adult Blood Lead Epidemiology and Surveillance (ABLES) Program

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This is the summary of the eighteenth and nineteenth year of the results of blood lead levels (BLLs) in Michigan and covers individuals 16 years and older whose blood lead was tested in Michigan in 2015 and 2016.

- In 2015, Michigan received 19,810 blood lead tests for 14,340 individuals who were ≥16 years old. Five hundred and eleven (3.6%) individuals had BLLs ≥10 micrograms per deciliter (µg/dL); 79 of those 511 had lead levels ≥25 µg/dL and four of the 79 had BLLs ≥50 µg/dL. Another 888 individuals had BLLs 5-9 µg/dL.

- In 2016, Michigan received 45,797 blood lead tests for 36,601 individuals who were ≥16 years old. Five hundred and thirty-one (1.5%) individuals had BLLs ≥10 µg/dL; 96 of those 531 had lead levels ≥25 µg/dL and nine of the 96 had BLLs ≥50 µg/dL. Another 1,116 individuals had BLLs 5-9 µg/dL.

- When individuals tested in both 2015 and 2016 are only counted once, there were 48,662 individuals of whom 846 (1.7%) individuals had BLLs ≥10 µg/dL, 157 (0.3%) had BLLs ≥25 µg/dL, and 12 (0.02%) had BLLs ≥50 µg/dL. Another 1,793 individuals (3.7%) had BLLs 5-9 µg/dL.

- Because of increased concern about lead generated by the Flint water contamination, there were 5,188 more blood lead tests and 1,810 more adults tested in 2015 compared to 2014 and 25,987 more blood lead tests and 22,261 more adults tested in 2016 compared to 2015.

- The number of individuals living in the Flint zip codes on Flint drinking water who had a blood lead test markedly increased from 2014 to 2015-2016; 123 to 15,675. The number of individuals with a BLL ≥5 µg/dL increased from 13 to 85. A separate report on BLLs in Flint adults tested for lead in 2015 and 2016 is being prepared.

- The number of individuals with BLLs ≥10 µg/dL increased from 507 (4.0%) in 2014 to 511 (3.6%) in 2015 and to 531 (1.5%) in 2016 while the percentage ≥10 µg/dL decreased in both years due to an increase in the number of individuals tested.

- The number of individuals with BLLs ≥25 µg/dL increased from 70 (0.6%) in 2014 to 79 (0.6%) in 2015 and to 96 (0.3%) in 2016; the percent decreased in 2016. The number of individuals with BLLs ≥50 µg/dL went from five (0.04%) in 2014 to four (0.03%) in 2015 but then increased to nine (0.02%) in 2016.

- For twelve consecutive years, from 1999 to 2010, there was a downward trend for BLLs ≥10 µg/dL and BLLs ≥25 µg/dL from the previous year. However, in 2011 and 2012 the number of BLLs ≥25 µg/dL increased from 102 in 2010 to 116 in 2011 and to 131 in 2012 and then dropped to 108 in 2013, to 70 in 2014 but then increased to 79 in 2015 and 96 in 2016. The overall trend for work and non-work exposures was similar showing a downward trend until 2005 with no further decrease from 2006 through 2014. In 2015, there was a decrease in elevated BLLs from non-work exposures but not from the work exposure. In 2016, there was a decrease in elevated blood lead levels from work while there was an increase from non-work exposures.

- Among adults with BLLs ≥10 µg/dL, work-related exposure was the predominant source of lead exposure (82.2%); including work in abrasive blasting to remove lead paint on outdoor metal structures such as bridges, overpasses or water towers; cleaning or refurbishing batteries; fabricating metal products; or exposure to lead fumes or dust from firing guns or retrieving spent bullets at firing ranges. Among the 18% with non-work-related exposure, 42% of lead exposure was from recreational shooting at firing ranges, reloading or casting of bullets.

- In 2015 and 2016, outreach and intervention activities included providing educational material to 191 individuals, follow-up interviews with 94 lead-exposed individuals, and distribution of resources on diagnosis and management of lead exposure to 50 health care providers whose patients had an elevated BLL. Up to four educational brochures were distributed depending on the source of the individual's exposure to lead: one on working safely with lead, the second on controlling lead exposure in firing ranges, a third on reducing lead exposure when reloading firearms or casting lead as a hobby (available at www.oem.msu.edu under Resources for Adult Blood Lead (ABLES)) and a fourth, a "how to" guide for home maintenance and renovation from the U.S. Department of Housing and Urban Development. Private gun clubs and ranges that are run by members and volunteers are not under the jurisdiction of State regulations as State regulations only cover businesses that have an employer/employee relationship. Outreach efforts to educate the group of lead-exposed hobbyists who use private clubs remained a challenge.

- Since 1998, Interviews of 538 adults with elevated BLL found that children in their household under the age of six who have been tested for lead were a high-risk group with 35.1% of the children having an elevated blood lead level of at least 10 µg/dL. The presumed source of exposure was lead brought home on the work clothes or shoes of the adult exposed at work.

- Michigan Occupational Safety and Health Administration (MIOSHA) inspected

four companies for elevated blood lead laboratory reports in 2015-2016 and all received lead-related citations. One other company, which was inspected by federal OSHA, also received a lead-related citation.

BACKGROUND

This report contains data from the eighteenth and nineteenth year of surveillance of BLLs in Michigan. It provides detailed data on residents, who were ≥16 years old, whose blood lead was tested in Michigan in 2015 and 2016. It provides annual trend data going back to 1999.

BLLs, including those of children, have been monitored by the State since 1992. From 1992 to 1995, laboratories performing analyses of blood lead levels, primarily of children, voluntarily submitted reports to the State. The State of Michigan health department (called the Michigan Department of Community Health until May 2015 when it was renamed the Department of Health and Human Services (MDHHS)) promulgated regulations effective October 11, 1997, that require laboratories to submit reports of both children and adults for any blood testing for lead to the MDHHS. Coincident with the promulgation of this regulation in 1997, Michigan received federal funding from the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC) to monitor adult BLLs as part of the ABLES program. The NIOSH ABLES surveillance program defines “adults” as individuals 16 years or older. The Michigan ABLES program adopted the NIOSH ABLES definition of the adults. Up to 41 states established lead registries through the ABLES program for surveillance of adult lead absorption, primarily based on reports of BLLs from clinical laboratories. Because of cutbacks in funding, 28 states currently participate. The most recent report of U.S. adult blood lead surveillance, published in the *Morbidity and Mortality Weekly Report*, October 14, 2016 / 63(55):59-65, is in Appendix A (1).

Surveillance for lead exposure in adults has focused on occupational exposure because 80% or more of adults with elevated lead levels have had their exposure at work. MIOSHA has two legal standards related to employer responsibilities for preventing lead exposure in employees – one for general industry and one for construction. Both of these have requirements for employee medical monitoring, including blood lead testing, and medical removal. See Appendix B for a summary of the two standards.

The MIOSHA requirements for medical surveillance and medical removal are identical to those of Federal OSHA. The requirements for medical removal differ between general industry and construction. For general industry, an individual must have two consecutive BLLs above 60 µg/dL or an average of three BLLs greater than 50 µg/dL before being removed (i.e. taken pursuant to the standard or the average of all blood tests conducted over the previous six months, whichever is longer). For construction, an individual needs to have only two consecutive blood lead level measurements above 50 µg/dL. However, an employee is not required to be removed if the last blood lead test is

≤40 µg/dL. If monitoring shows lead levels above 30 micrograms per cubic meter of air (µg/m^3) calculated as an 8-hour time-weighted average (TWA) (MIOSHA's action limit) but below 50 µg/m^3 averaged over an 8-hour period (permissible exposure limit (PEL)), an employer also must implement routine air monitoring; training; medical surveillance, including blood testing for lead and zinc protoporphyrin, medical exams and consultation; and provide medical removal protection for employees with excessively elevated blood lead levels. See Appendix B for a more detailed description of the requirements.

It should be noted that in the absence of a specific exposure to lead, 95% of BLLs in the adult general population in the U.S. are below 3.8 µg/dL for men and below 2.8 µg/dL for women (2). Also of note, in 2012, the CDC recommended public health actions be initiated for children at the reference level of 5 µg/dL or greater, but did not review this issue for adults (3). The CDC had previously considered blood leads of 10 µg/dL or greater as a level of concern. Both the Association for Occupational and Environmental Clinics (AOEC) (4) and the Council for State and Territorial Epidemiologists (CSTE) (5) have adopted medical guidelines that recommend a medical response for levels of 5 µg/dL or greater in adults, and in 2014, the CSTE recommended that a BLL of 5µg/dL or greater be considered elevated for adults, as well as children, and that surveillance for adults reflect this definition change (6).

A summary of reference blood lead values for adults is in Appendix C and recommendations for medical management on lead exposed individuals is in APPENDIX D.

THE MICHIGAN ADULT BLOOD LEAD REGISTRY

METHODS

Reporting Regulations and Mechanism

Since October 11, 1997, laboratories performing blood lead analyses have been required to report the results of all blood lead tests to the MDHHS. These rules were amended in 2015 to cover blood lead testing in doctors' offices (R 325.9081- 325.9086). Prior to 1997, few reports of elevated blood lead levels among adults were received.

The laboratories are required to report blood sample analysis results, patient demographics, and employer information electronically. The healthcare provider ordering the blood lead analysis is responsible for completing the patient information, the physician/provider information and the specimen collection information. Upon receipt of the blood sample for lead analysis, the clinical laboratory is responsible for

completion of the laboratory information. All clinical laboratories conducting business in Michigan that analyze blood samples for lead must report all adult and child blood lead results electronically to the MDHHS Childhood Lead Poisoning Prevention Program (CLPPP) within five working days.

Employers providing blood lead analysis on their employees, as required by MIOSHA, must use a laboratory, which meets OSHA proficiency testing for blood lead analysis, to comply with the lead standard. Table 1 lists the five OSHA-approved laboratories in Michigan.

Table 1. Michigan Laboratories Meeting OSHA Proficiency Testing for Blood Lead Analysis

MICHIGAN BLOOD LEAD LABORATORIES*

Laboratory Name	*City*
DMC University Laboratories	Detroit
Michigan Department of Health and Human Services	Lansing
Regional Medical Laboratories	Battle Creek
Sparrow Health System	Lansing
Warde Medical Laboratories	Ann Arbor

***Laboratories which meet OSHA's accuracy requirements in blood lead proficiency testing as of September 19, 2017. For a complete listing of OSHA-approved blood lead laboratories, visit the OSHA web site at https://www.osha.gov/SLTC/bloodlead/state_list.html**

Data Management

The MDHHS CLPPP forwards the electronic record of all blood lead results on individuals ≥ 16 years old to the ABLES program at Michigan State University, the bona fide agent of the State for adult blood lead surveillance, where they are uploaded to an Access database. The database includes identifiers, demographics, information about source of exposure to lead, and name/address of employer for work-related exposures. Only venous blood leads are entered into the database. Urine, hair and capillary lead levels were excluded.

When BLL reports were received, they were reviewed for completeness. For blood lead

reports ≥10 µg/dL that were incomplete, requests were sent to the provider who ordered the test to provide the missing information. No follow-up was performed for BLLs less than 10 µg/dL, with the exception of Flint residents where follow up was performed for BLLs of 5 µg/dL or greater. Each record entered into the database had a visual quality control check on a monthly basis for any data entry errors, duplicate entries, missing data, and illogical data.

Case Follow-Up

An adult who has a BLL 25 µg/dL or greater was contacted for an interview. Interviews were also conducted of individuals with BLLs ranging from 10 to 24 µg/dL if the source of their lead exposure cannot be identified from the laboratory report. Since 2016, all Flint residents with a blood lead level 5 µg/dL or greater are contacted for an interview. A letter is sent to these individuals explaining Michigan's lead surveillance program and inviting them to answer a 15-20 minute telephone questionnaire about their exposures to lead and any symptoms they may be experiencing. The questionnaire collects patient demographic data, work exposure and history information, symptoms related to lead exposure, information on potential lead-using hobbies and non-work related activities, and the presence of young children in the household to assess possible take-home lead exposures among these children. Trained interviewers administer the questionnaire.

For those individuals with BLLs of 25 µg/dL or greater whose exposure is work, the Michigan Occupational Safety and Health Administration (MIOSHA) of the Michigan Department of Licensing and Regulatory Affairs (LARA) makes a determination on the utility of conducting a workplace follow-up.

Dissemination of Surveillance Data

In addition to Michigan's annual ABLES surveillance summaries, Michigan's ABLES data, without personal identifiers, are forwarded once a year to the program's funding agency, NIOSH at the CDC. NIOSH compiles surveillance summaries using data from all states that require reporting of BLLs and publishes them in the Morbidity and Mortality Weekly Report (MMWR) (1). See Appendix A for the most recent publication of ABLES surveillance results for the period 1994-2013.

This annual report provides a summary of data from reports of all adult BLLs received in 2015 and 2016 along with annual trends in numbers of adults reported with elevated BLLs going back to 1998. Also included is information about the MIOSHA inspections completed in 2015 and 2016 at the worksites where reported individuals were exposed to lead. Information is provided on households where adults with elevated BLLs reported children age six and younger living or spending time in the home.

There is strong medical evidence of health effects at levels as low as 5 µg/dL (4-7), but the program has insufficient resources to determine the source of exposure for the many individuals with BLLs <10 µg/dL (Table 2), with an exception for Flint residents.

For Tables 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11, and Figures 5, 6, 7, 8, 9 and 10 which show combined data for 2015-2016, individuals with blood leads testing in both years are counted only once and only the highest blood lead of the two years was used; therefore the totals for the data in Figures 1, 2, 3, 4 and 12 for the individual years 2015 and 2016 differ from the totals for the data of the combined years.

RESULTS

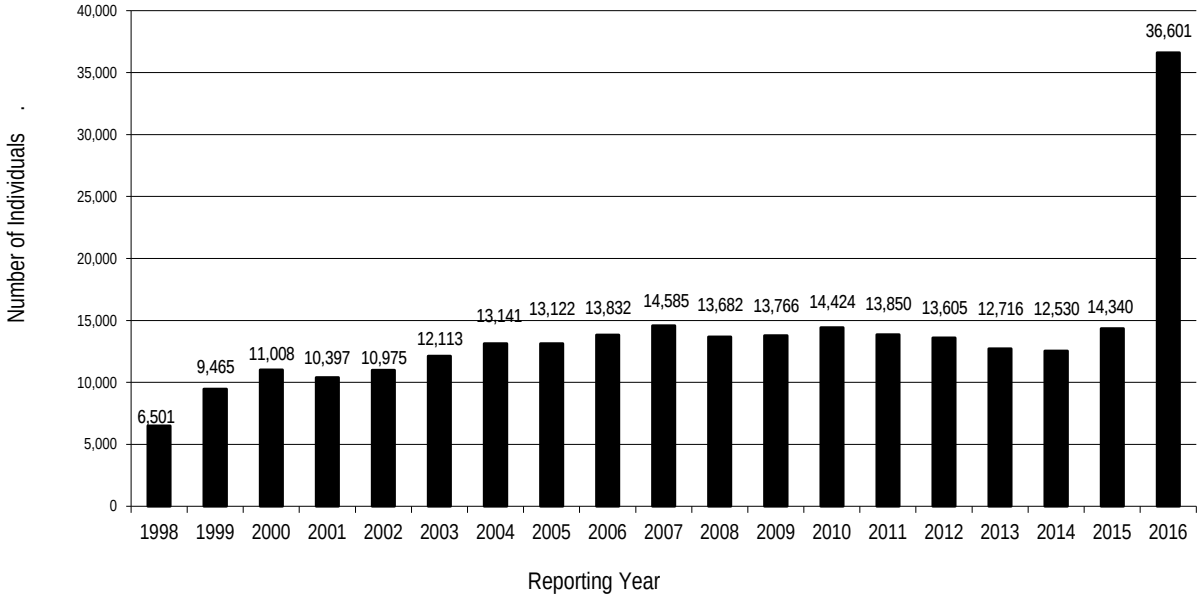
This is the eighteenth year with complete laboratory reporting in Michigan since the lead regulations became effective on October 11, 1997.

Number of Reports and Individuals

2015-2016: Between January 1, 2015 and December 31, 2016, the State of Michigan received 65,607 blood lead test reports for individuals ≥16 years old. Because an individual may be tested more than once each year, and/or during two consecutive years, the 65,607 reports received were for 48,662 individuals. Between January 1 and December 31, 2015, the State of Michigan received 19,810 BLLs on 14,340 individuals and between January 1 and December 31, 2016, 45,797 reports for 36,601 individuals (Figure 1). Two thousand two hundred and seventy-nine individuals had blood lead test reports in both 2015 and 2016.

1998-2016 trends: Up to 2007, the overall trend for the number of individuals tested each year showed a gradual increase (Figure 1). The initial increase in 1999 and 2000 was most likely also due to better compliance by the laboratories with the 1997 reporting regulation. The increase after 2000 is assumed to be increased testing while the drop in numbers of tests noted in 2008 and 2009 was likely a reflection of the economic downturn. The reduction in 2013 and 2014 probably reflects a reduced number of companies conducting blood lead monitoring on their employees. The reason for the most recent marked increase in the number of individuals tested was due to increased testing for lead in the City of Flint (Genesee County).

Figure 1. Number of Adults Reported with Tests for Blood Lead, Michigan 1998-2016



Distribution of BLLs and exposure sources:

(Note: For individuals with multiple BL tests, only the highest BLL is included. The same individual may be included in multiple years.)

2015-2016 Combined: In 2015 and 2016, 846 (1.7%) of the 48,662 adults reported had BLLs ≥10 µg/dL; 157 of those 846 had BLLs ≥25 µg/dL and 12 of 157 had BLLs ≥50 µg/dL (Table 2).

A total of 46,023 (94.6%) of adults reported in 2015 and 2016 had BLL less than 5 µg/dL, and 1,793 (3.7%) were from individuals whose blood lead was 5–9 µg/dL. Individuals with BLL 5–9 µg/dL are not routinely contacted; however when the source of lead exposure was identified on the lab report, 198 of 267 (74.2%) individuals were identified as occupationally exposed. One hundred and twenty-three (62.1%) of these 198 had been tested in previous years and 77 of the 123 (62.6%) showed a decrease in their BLL. Among the 689 individuals whose blood lead was 10–24 µg/dL, 502 (72.9%) individuals had their source of lead exposure identified as occupational as compared to the 111 of 157 (70.7%) of individuals with BLLs ≥25 µg/dL.

Table 2. Distribution of Highest Blood Lead Levels among Adults and Source of Exposure in Michigan: 2015-2016

BLLs (µg/dL)	Work*		Non-Work		Source Not Yet Identified		All BLLs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
<5	273	25.1 [a]	19	8.6[a]	45,731	96.6[a]	46,023	94.6
5-9	198	18.3[a]	69	31.4[a]	1,526	3.2[a]	1,793	3.7
10-24	502	46.3	103	46.6	84	0.2	689	1.4
25-29	40	3.7	14	6.3	7	-	61	0.1
30-39	57	5.3	10	4.5	7	-	74	0.2
40-49	8	0.7	0	-	2	-	10	-
50-59	4	0.4	3	1.4	0	-	7	-
≥ 60	2	0.2	3	1.4	0	-	5	-
Total	**1,084**	**83.1[b]**	**221**	**16.9[b]**	**47,357**	**100.0**	**48,662[c]**	**100.0**
Total ≥10µg/dL	**613**	**82.2[d]**	**133**	**17.8[d]**	**100**	**0.2**	**846**	**1.7**
Total ≥25µg/dL	**111**	**78.7[e]**	**30**	**21.3[e]**	**16**	**0.03**	**157**	**0.3**

*Work category includes 10 adults with BLLs ≥10 µg/dL whose exposure to lead was both work and non-work activities.

a No follow-up is conducted of individuals with blood lead test results <10 µg/dL, but often information is known.

b Percent of total known exposures

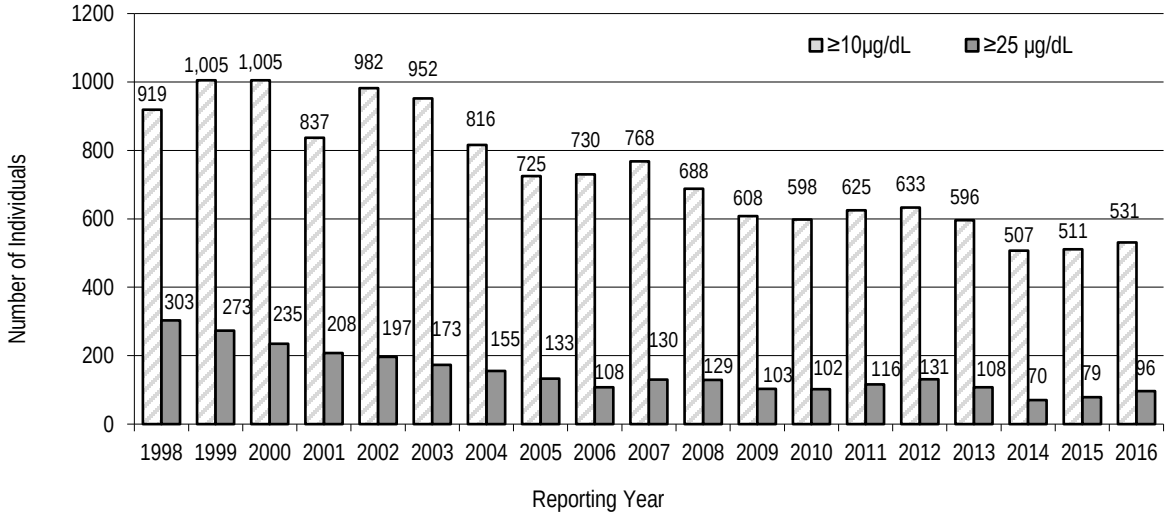
c In 2015-16, 65,607 BLL reports were received for 48,662 individuals.

d Percent of known exposures ≥10 µg/dL

e Percent of known exposures ≥25 µg/dL

1998-2016 trends: For twelve consecutive years, from 1999 to 2010, there was a downward trend for BLLs ≥10 µg/dL and BLLs ≥25 µg/dL from the previous year (Figure 2). In 2011 and 2012, the number of BLLs ≥10 µg/dL and ≥25 µg/dL increased, and in 2013 and 2014, the number dropped again. In 2015 and 2016, both BLLs ≥10 µg/dL and ≥25 µg/dL levels increased to 511 and 532, and to 79 and 96, respectively.

Figure 2. Number of Adult BLLs ≥10 µg/dL and ≥25 µg/dL, Michigan 1998-2016



There was a marked decline in the overall number of individuals with elevated blood lead from occupational exposure from 2000 to 2005, the number remained fairly stable from 2006 to 2012, then declined in 2013 and 2014, increased in 2015 and declined in 2016 (Figure 3). For non-work exposures, elevated blood lead showed a decline from 2003 to 2006, a slight increase in 2007 and 2008, and then a slight change from 2009 to 2013, a more marked decrease in 2014 and 2015, and an increase in 2016 (Figure 4).

Figure 3. Number of Adults with Elevated BLLs due to Work Exposure, Michigan 1998-2016

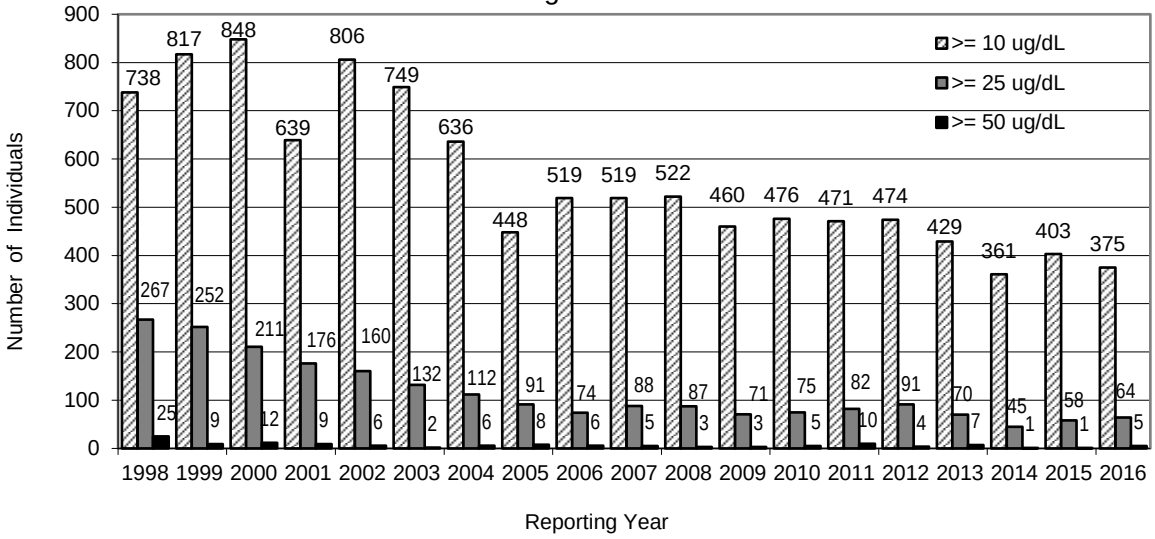
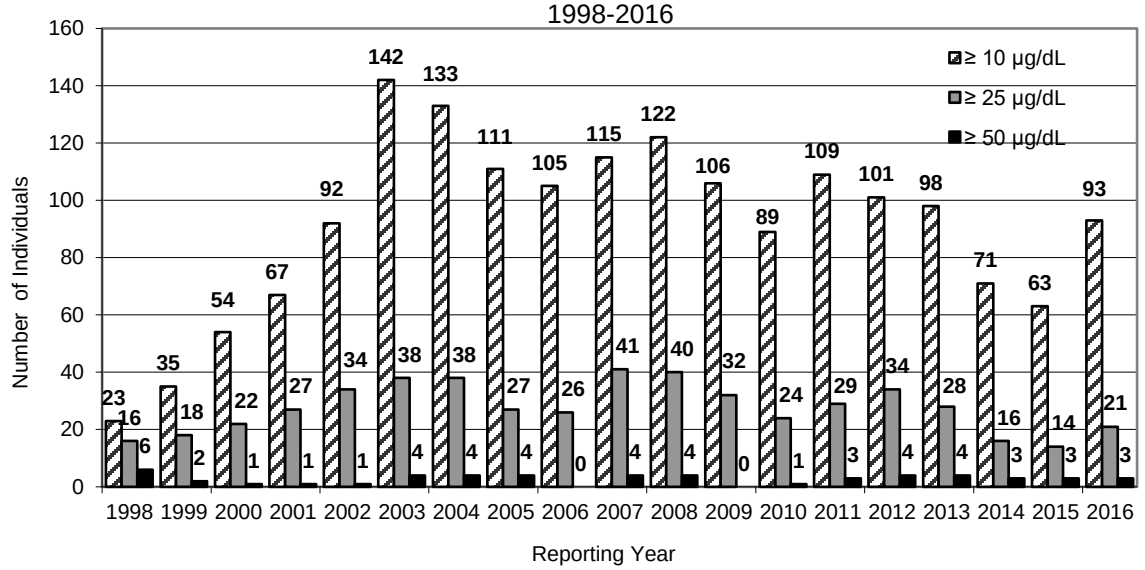


Figure 4. Adults with Elevated BLLs from Non-Work Exposure, Michigan 1998-2016



GENDER AND AGE: 2015-2016

All Blood Lead Levels

Fifty-three percent of the adults reported to ABLES were female, and forty-seven percent were male (Table 3). The mean age was 46.5 and median age 46.8. The age distribution is shown in Table 4.

Table 3. Distribution of Gender among of Adults Tested for BLLs in Michigan: 2015-2016

Gender	All Blood Lead Level Tests		All Blood Lead Levels ≥10 µg/dL		All Blood Lead Levels ≥25 µg/dL	
	Number	Percent	Number	Percent	Number	Percent
Male	22,775	46.9	784	92.7	144	94.1
Female	25,825	53.1	62	7.3	9	5.9
Total	48,600[a]	100.0	846	100.0	153[b]	100.0

[a] Gender was unknown for 62 additional individuals.
[b] Gender was unknown for 4 additional individuals.

Table 4. Distribution of Age Among Individuals Tested for Blood Lead in Michigan: 2015-2016

Age Range	All Blood Lead Level Tests		Blood Lead Levels ≥10 µg/dL	
	Number	Percent	Number	Percent
16-19	3,555	7.3	11	1.3
20-29	7,993	16.4	127	15.0
30-39	7,669	15.8	184	21.8
40-49	7,728	15.9	196	23.2
50-59	9,453	19.4	193	22.8
60-69	7,090	14.6	100	11.8
70-79	3,540	7.3	28	3.3
80-89	1,448	3.0	7	0.8
90-99	166	0.3	0	-
100+	19	-	0	-
Total	48,661[a]	100.0	846	100.0

[a] Age was unknown for one additional individual.

BLLs ≥10 µg/dL

For the 846 adults reported to the Registry with BLLs ≥10 µg/dL, 784 (92.7%) were men and 62 (7.3%) were women. The mean age was 45.4 and median age was 44.9.

RACE DISTRIBUTION

All Blood Lead Levels

Although laboratories are required to report the patient's race, this information was frequently not provided. Race was missing for 34,416 (70.7%) of the 48,663 adults reported in 2015 and 2016. In the 14,247 reports where race was known, 9,395 (65.9%) were reported as Caucasian, 4,479 (31.5%) were reported as African American, 158 (1.1%) were reported as Asian/Pacific Islander, 134 (0.9%) were reported as Native American, and 81 (0.6%) were reported as Multi-racial/Other (Table 5). Information on Hispanic ethnicity was missing for an even higher percentage, 47,499 (97.6%) of the 48,663 adults.

Table 5. Distribution of Race among Adults Tested for Blood Lead in Michigan: 2015-2016

Race	All Blood Lead Level Tests		Blood Lead Levels ≥10 µg/dL	
	Number	Percent	Number	Percent
Caucasian	9,395	65.9	346	76.7
African American	4,479	31.5	65	14.4
Asian/Pacific Islander	158	1.1	8	1.7
Native American	134	0.9	16	3.6
Multiracial/Other	81	0.6	16	3.6
Total	14,247[a]	100.0	451[b]	100.0

[a] Race was unknown for 34,415 additional individuals.
[b] Race was unknown for 395 additional individuals.

BLLs ≥10 µg/dL

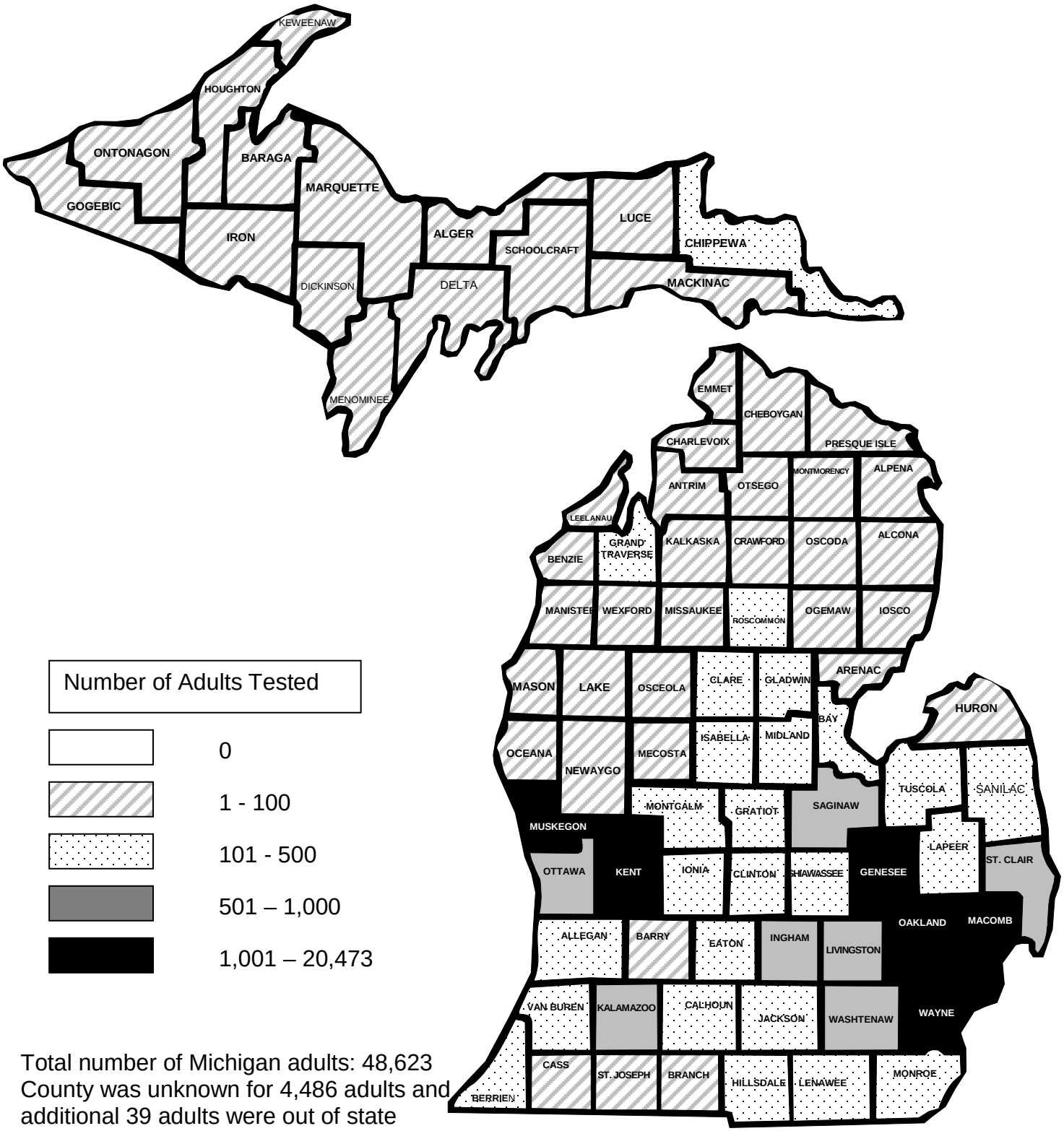
For adults with BLLs greater than or equal to 10 µg/dL where race was indicated, 346 (76.7%) were reported as Caucasian, 65 (14.4%) were reported as African American, 16 (3.6%) were reported as Native American, 16 (3.6%) were reported as Multiracial/Other, and eight (1.7%) was reported as Asian/Pacific Islander (Table 5).

There were 46 individuals of Hispanic ethnicity with a blood lead ≥10 µg/dL.

GEOGRAPHIC DISTRIBUTION

County of residence was determined for 44,137 of the 48,662 adults reported to the Registry. They lived in all of Michigan's 83 counties. The largest number of adults tested in 2015 and 2016 lived in Genesee County (20,473, 46.4%), followed by Wayne County (4,229, 9.6%) and Oakland County (2,746, 6.2%). The county was unknown for 4,486 adults tested for blood lead (Figure 5 and Table 6).

Figure 5. Geographic Distribution of Adults Tested for Lead In Michigan by County of Residence, 2015-2016



Total number of Michigan adults: 48,623
County was unknown for 4,486 adults and additional 39 adults were out of state

Genesee and Wayne counties had the highest number of adults tested with 20,473 and 4,229 respectively.

Table 6. Number and Percent of Adults with All Blood Lead Levels (BLLs), BLLs ≥10 µg/dL and ≥25 µg/dL by County of Residence and Percent of Adults with BLLs ≥10 µg/dL and ≥25 µg/dL among All Adults Tested for BLL in Each County of Residence in Michigan: 2015-2016

	All BLLs		BLLs >10 µg/dL			BLLs >25 µg/dL		
County	Number	Percent	Number	Percent of all BLLs in State	Percent of all BLLs in County	Number	Percent of all BLLs in State	Percent of all BLLs in County
Alcona	20	-	0	-	-	0	-	-
Alger	11	-	0	-	-	0	-	-
Allegan	266	0.6	5	0.8	1.9	0	-	-
Alpena	45	0.1	0	-	-	0	-	-
Antrim	79	0.2	2	0.3	2.5	0	-	-
Arenac	36	0.1	1	0.2	2.8	1	0.9	2.8
Baraga	12	-	1	0.2	8.3	0	-	-
Barry	98	0.2	3	0.5	3.1	1	0.9	1.0
Bay	257	0.6	5	0.8	1.9	1	0.9	0.4
Benzie	24	0.1	0	-	-	0	-	-
Berrien	117	0.3	8	1.3	6.8	1	0.9	0.9
Branch	43	0.1	1	0.2	2.3	0	-	-
Calhoun	237	0.5	7	1.1	3.0	3	2.7	1.3
Cass	30	0.1	2	0.3	6.7	0	-	-
Charlevoix	53	0.1	1	0.2	1.9	1	0.9	1.9
Cheboygan	58	0.1	3	0.5	5.2	2	1.8	3.4
Chippewa	162	0.4	7	1.1	4.3	3	2.7	1.9
Clare	157	0.4	8	1.3	5.1	1	0.9	0.6
Clinton	228	0.5	5	0.8	2.2	1	0.9	0.4
Crawford	41	0.1	0	-	-	0	-	-
Delta	47	0.1	1	0.2	2.1	1	0.9	2.1
Dickinson	21	-	4	0.6	19.0	0	-	-
Eaton	355	0.8	9	1.4	2.5	3	2.7	0.8
Emmet	74	0.2	2	0.3	2.7	1	0.9	1.4
Genesee	20,473	46.4	60	9.6	0.3	7	6.2	-
Gladwin	117	0.3	2	0.3	1.7	0	-	-
Gogebic	18	-	0	-	-	0	-	-
Grand Traverse	165	0.4	5	0.8	3.0	1	0.9	0.6
Gratiot	222	0.5	3	0.5	1.4	0	-	-
Hillsdale	101	0.2	2	0.3	2.0	1	0.9	1.0
Houghton	49	0.1	0	-	-	0	-	-
Huron	47	0.1	2	0.3	4.3	0	-	-
Ingham	785	1.8	12	1.9	1.5	1	0.9	0.1
Ionia	168	0.4	5	0.8	3.0	0	-	-
Iosco	38	0.1	0	-	-	0	-	-
Iron	16	-	0	-	-	0	-	-
Isabella	264	0.6	1	0.2	0.4	1	0.9	0.4
Jackson	210	0.5	8	1.3	3.8	2	1.8	1.0
Kalamazoo	575	1.3	13	2.1	2.3	2	1.8	0.3
Kalkaska	84	0.2	1	0.2	1.2	0	-	-
Kent	2,182	4.9	19	3.1	0.9	5	4.4	0.2
Keweenaw	4	-	0	-	-	0	-	-
Lake	15	-	0	-	-	0	-	-
Lapeer	359	0.8	2	0.3	0.6	0	-	-

Table 6 continued. Number and Percent of Adults with All Blood Lead Levels (BLLs), BLLs ≥10 µg/dL and ≥25 µg/dL by County of Residence and Percent of Adults with BLLs ≥10 µg/dL and ≥25 µg/dL among All Adults Tested for BLL in Each County of Residence in Michigan: 2015-2016

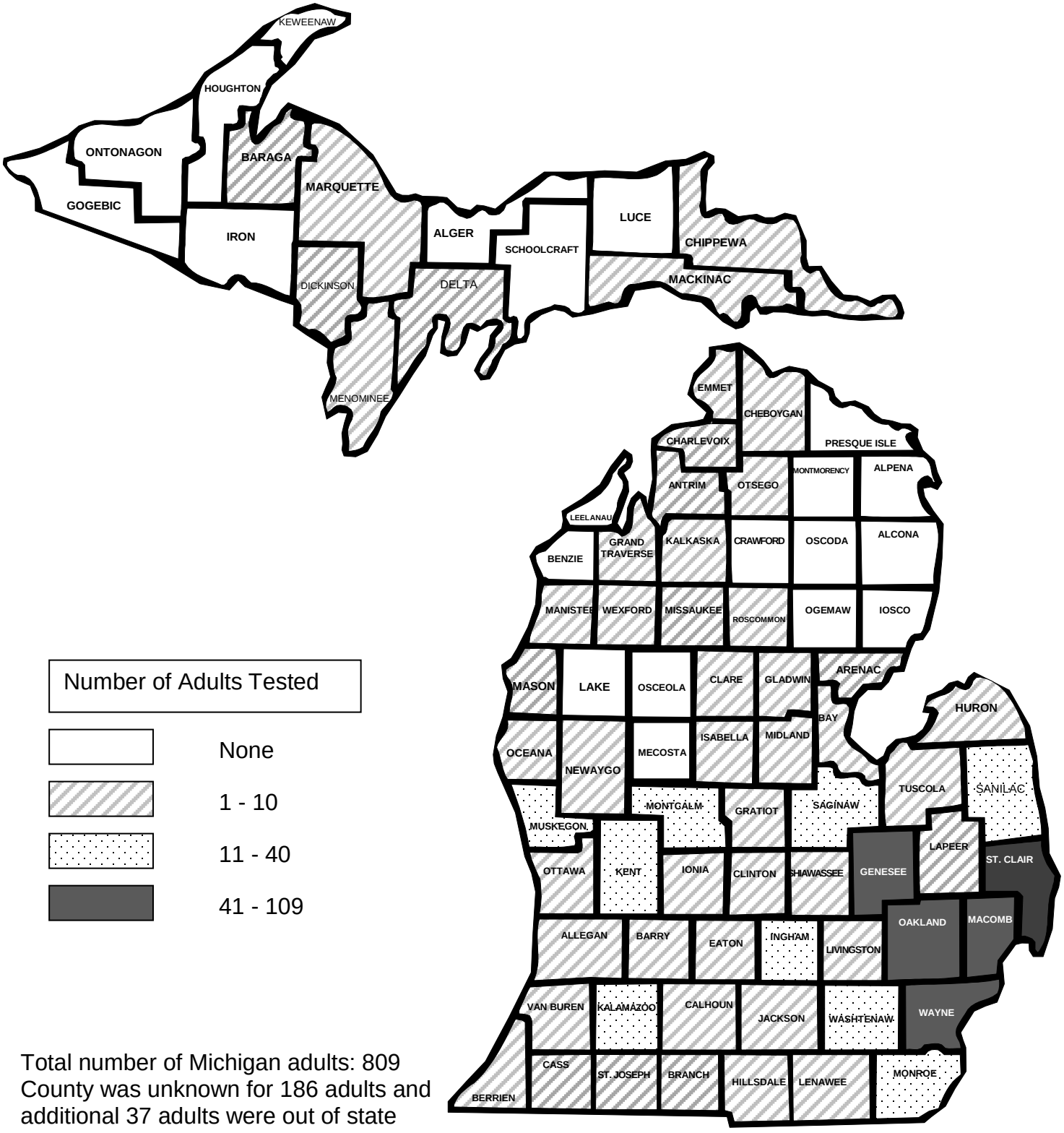
	All BLLs		BLLs >10 µg/dL			BLLs >25 µg/dL		
County	Number	Percent	Number	Percent of all BLLs in State	Percent of all BLLs in County	Number	Percent of all BLLs in State	Percent of all BLLs in County
Leelanau	31	0.1	0	-	-	0	-	-
Lenawee	180	0.4	9	1.5	5.0	2	1.8	1.1
Livingston	383	0.9	10	1.6	2.6	1	0.9	0.3
Luce	6	-	0	-	-	0	-	-
Mackinac	68	0.2	6	1.0	8.8	1	0.9	1.5
Macomb	1,689	3.8	47	7.6	2.8	11	9.8	0.7
Manistee	60	0.1	1	0.2	1.7	0	-	-
Marquette	44	0.1	2	0.3	4.5	1	0.9	2.3
Mason	36	0.1	2	0.3	5.6	0	-	-
Mecosta	67	0.2	0	-	-	0	-	-
Menominee	18	-	2	0.3	11.1	0	-	-
Midland	238	0.5	3	0.5	1.3	0	-	-
Missaukee	24	0.1	1	0.2	4.2	1	0.9	4.2
Monroe	480	1.1	17	2.8	3.5	2	-	0.4
Montcalm	222	0.5	16	2.6	7.2	1	0.9	0.5
Montmorency	17	-	0	-	-	0	-	-
Muskegon	1,021	2.3	19	3.1	1.9	1	0.9	0.1
Newaygo	55	0.1	1	0.2	1.8	0	-	-
Oakland	2,746	6.2	47	7.6	1.7	12	10.7	0.4
Oceana	93	0.2	1	0.2	1.1	0	-	-
Ogemaw	24	0.1	0	-	-	0	-	-
Ontonagon	7	-	0	-	-	0	-	-
Osceola	74	0.2	0	-	-	0	-	-
Oscoda	7	-	0	-	-	0	-	-
Otsego	57	0.1	2	0.3	3.5	1	0.9	1.8
Ottawa	526	1.2	6	1.0	1.1	3	2.7	0.6
Presque Isle	26	0.1	0	-	-	0	-	-
Roscommon	133	0.3	5	0.8	3.8	0	-	-
Saginaw	540	1.2	12	1.9	2.2	1	0.9	0.2
Saint Clair	993	2.2	45	7.3	4.5	6	5.3	0.6
Saint Joseph	71	0.2	5	0.8	7.0	0	-	-
Sanilac	109	0.2	12	1.9	11.0	0	-	-
Schoolcraft	9	-	0	-	-	0	-	-
Shiawassee	391	0.9	7	1.1	1.8	1	0.9	0.3
Tuscola	126	0.3	2	0.3	1.6	0	-	-
Van Buren	159	0.4	2	0.3	1.3	0	-	-
Washtenaw	643	1.5	15	2.4	2.3	2	1.8	0.3
Wayne	4,229	9.6	109	17.6	2.6	27	24.0	0.6
Wexford	72	0.2	2	0.3	2.8	0	-	-
TOTAL	**44,137[a]**	100.0	**623[b]**	100.0	1.4	**113[c]**	100.0	0.3

[a] County was unknown for 4,486 additional adults and 39 lived out of state.

[b] County was unknown for 186 additional adults and 37 lived out of state.

[c] County was unknown for 27 adults and 17 lived out of state.

Figure 6. Geographic Distribution of Adults Tested with BLLs ≥10 µg/dL In Michigan by County of Residence, 2015-2016



Total number of Michigan adults: 809
County was unknown for 186 adults and additional 37 adults were out of state

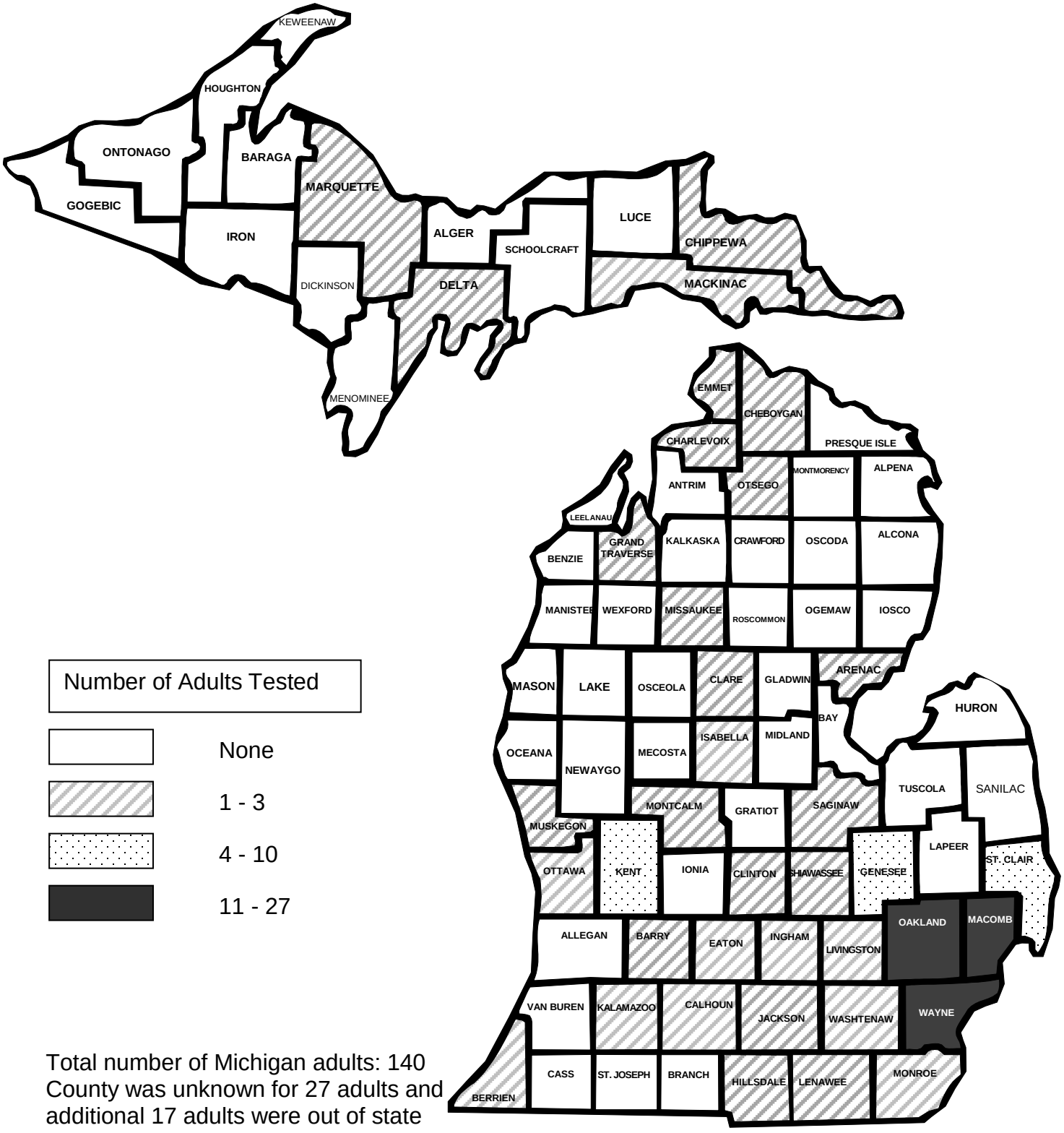
Wayne, Genesee and Macomb counties had the largest number of adults with BLLs ≥10 µg/dL, with 109, 60 and 47 respectively.

Figure 6 and Table 6 show the county of residence of the 623 adults with BLLs ≥10 µg/dL where county of residence could be determined. The largest number of adults reported with a BLL ≥10 µg/dL were from Wayne County (109, 17.6%), followed by Genesee County (60, 9.6%) and Macomb and Oakland Counties (both 47, 7.6%). The county was unknown for 186 adults with BLLs ≥10 µg/dL. Thirty-seven lived outside of Michigan.

Figure 7 and Table 6 show the county of residence for the 113 adults with BLLs ≥25 µg/dL where county of residence could be determined. The largest number of adults reported with a BLL ≥25 µg/dL were from Wayne County (27, 24.0%), followed by Oakland County (12, 10.7%), and Macomb County (11, 9.8%). The county was unknown for 27 adults with BLLs ≥25 µg/dL. Seventeen lived outside of Michigan.

Table 6 shows the percentage of tested adults in each county with BLLs ≥10 µg/dL and BLLs ≥25 µg/dL. Dickinson (19.0%), Menominee (11.1%), and Sanilac (11.0%) counties had the highest percentages of adults with BLL ≥10 µg/dL within their respective counties. Missaukee (4.2%), Cheboygan (3.4%), and Arenac (2.8%) counties had the highest percentage of tested adults with BLL ≥25 µg/dL.

Figure 7. Geographic Distribution of Adults Tested with BLLs ≥25 µg/dL In Michigan by County of Residence, 2015-2016



Total number of Michigan adults: 140
County was unknown for 27 adults and additional 17 adults were out of state

Wayne, Oakland and Macomb counties had the largest number of adults with BLLs ≥25 µg/dL, with 27, 12 and 11 respectively.

GENDER DISTRIBUTION

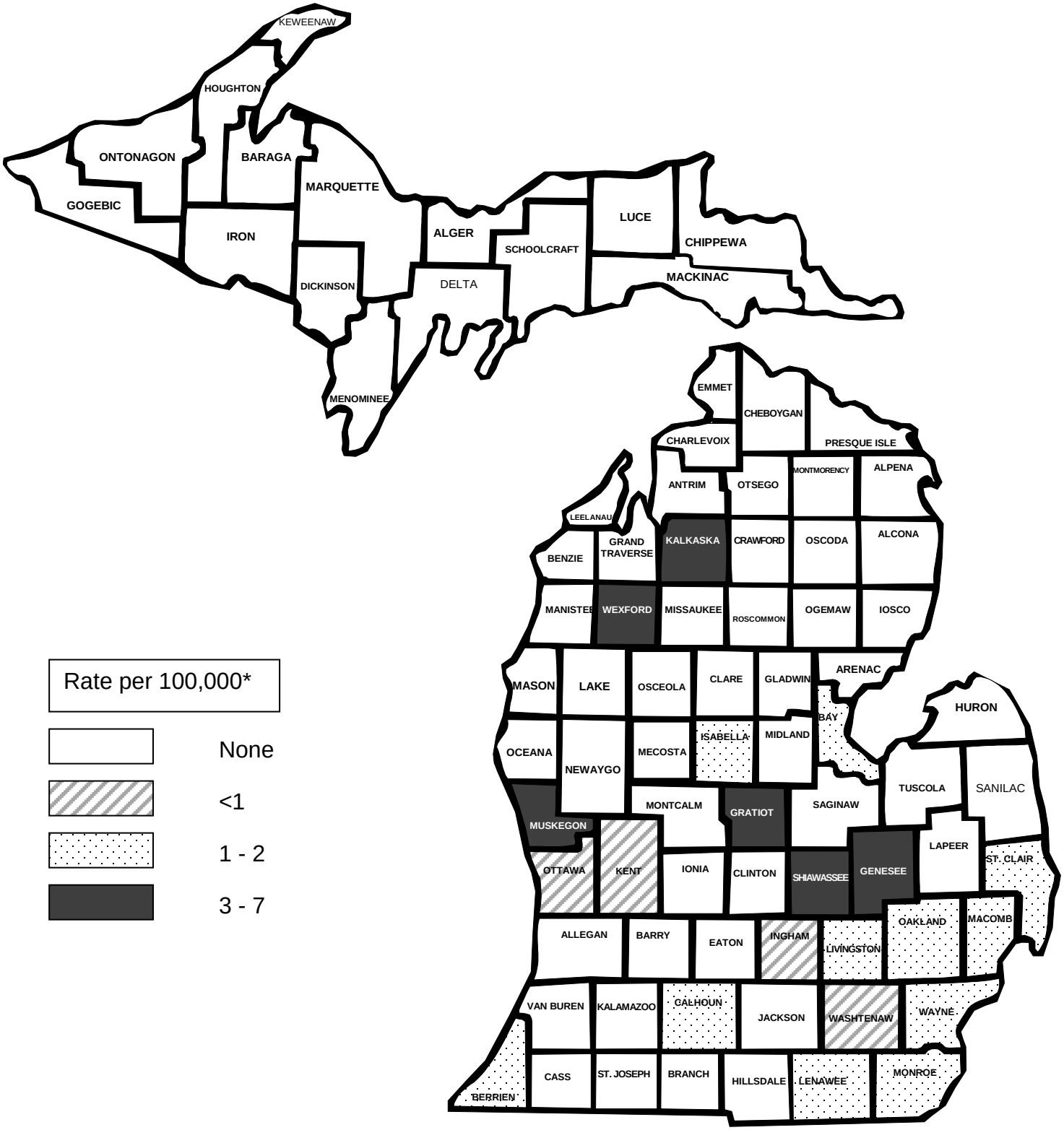
Women: Figure 8 and Table 7 show the incidence rates of BLL ≥10 µg/dL by county for women. There were 57 women reported in 2015 and 2016 with a BLL ≥10 µg/dL, where county was known. County of residence was unknown for an additional five women. Kalkaska (7/100,000), Wexford (4/100,000), and Shiawassee (4/100,000), had the three highest incidence rates.

Twenty-four women (50%) with elevated blood lead were exposed at work: five at a finish carpentry contractor, three at electric services companies, three in construction work, two at a gun range, two at a brass manufacturer, one with a law enforcement agency, one at a university, one at a metal stampings manufacturer, one at an automotive stampings manufacturer, one at a battery recycling company, one at a storage battery manufacturer, one at a non-ferrous foundry, one at an iron and steel mill and one individual with an unknown work exposure.

Twenty-four women (50%) with elevated blood leads had non-work exposures: five from a gunshot wound, five presumed from drinking water, four from home remodeling, four from food (e.g. spice), three had environmental exposure, two from firearms, and one swallowed a musket ball.

The source of exposure was unknown for fourteen of the 62 women.

Figure 8. Annual Incidence of BLLs ≥10 µg/dL Among Women by County of Residence, Michigan 2015-2016



*Denominator for Rate per 100,000 women age 16+ is from U.S. Census Bureau of County Resident Population, Annual Estimate for July 1, 2016.

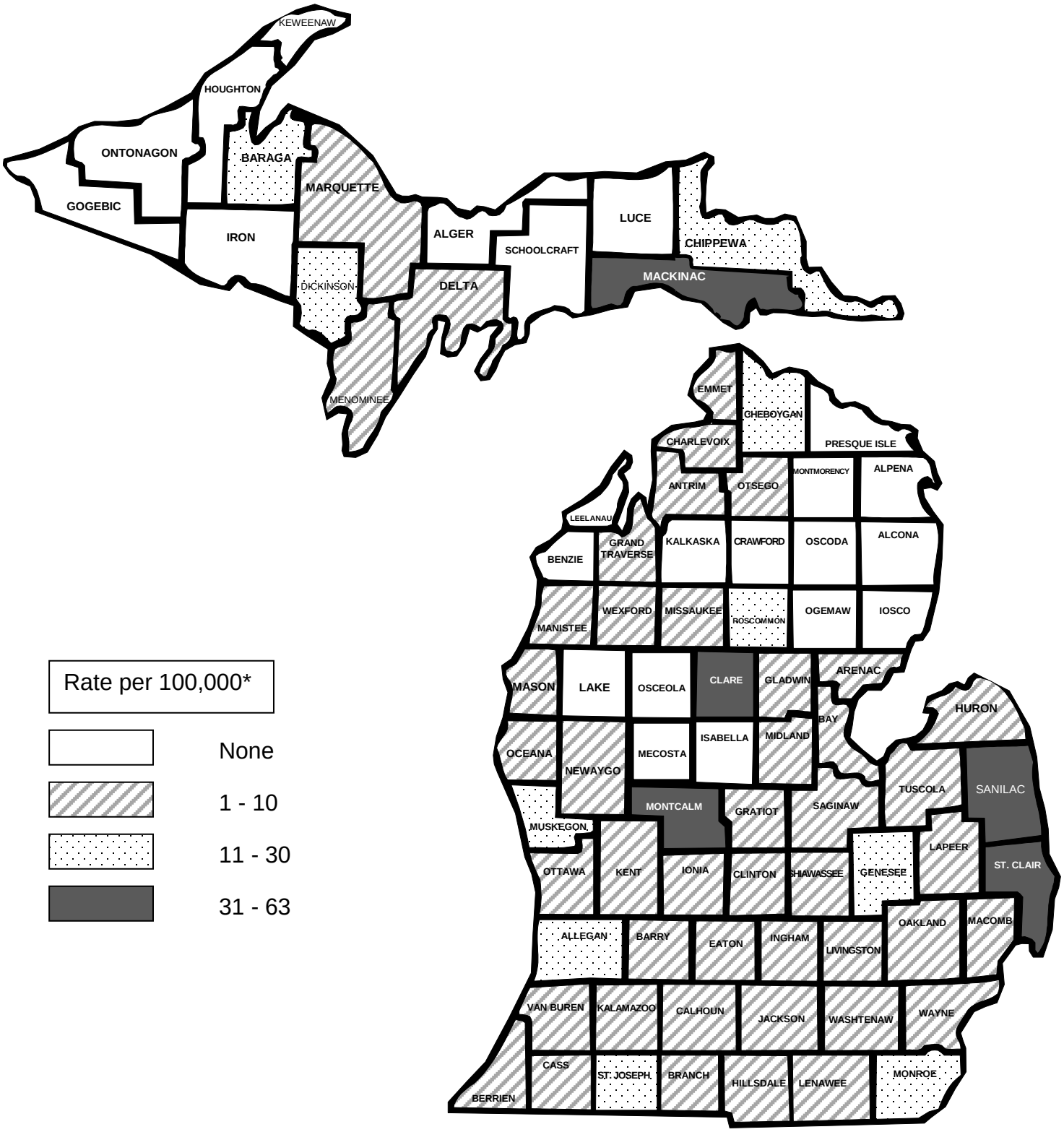
Table 7. Number and Rate of BLLs ≥10 µg/dL among Women in Michigan by County of Residence: 2015-2016

County	Number Reported	Michigan Population Women	Rate[c]
Bay	1	44,113	1
Berrien	2	63,782	2
Calhoun	1	55,339	1
Genesee	9	171,486	3
Gratiot	1	15,717	3
Ingham	1	122,897	0.4
Isabella	1	31,281	2
Kalkaska	1	6,873	7
Kent	1	257,132	0.2
Lenawee	1	39,684	1
Livingston	2	76,768	1
Macomb	5	363,340	1
Monroe	1	61,459	1
Muskegon	4	69,481	3
Oakland	7	522,745	1
Ottawa	1	113,242	0.4
Saint Clair	3	66,026	2
Shiawassee	2	28,362	4
Washtenaw	1	149,443	0.3
Wayne	11	726,152	1
Wexford	1	13,193	4
Total	57[a]	4,104,099[b]	1

[a] County was unknown for 5 additional women.
[b] Total number of women in all 83 counties of Michigan age 16+ years; 7/1/2016 County Characteristics Resident Population Estimates, U.S. Census Bureau.
[c] Rate per 100,000 women, age 16+ years.

Men: Figure 9 and Table 8 show the incidence rates of BLL of ≥10 µg/dL and above by county for men. There were 692 men reported in 2015 and 2016 with a BLL ≥10 µg/dL where county of residence could be determined. Mackinac (63/100,000), Sanilac (36/100,000), St. Clair (33/100,000) and Claire (32/100,000) had the highest incidence rates per 100,000 men based on the 2016 County Characteristics Resident Population Estimates from the U.S. Census Bureau. The overall incidence rate for men was 9 times higher than that for women (9/100,000 vs. 1/100,000) in 2015 and 2016.

Figure 9. Annual Incidence of BLLs ≥10 µg/dL Among Men by County of Residence, Michigan 2015-2016



*Denominator for Rate per 100,000 men age 16+ is from U.S. Census Bureau of County Resident Population, Annual Estimate for July 1, 2016.

Table 8. Number and Rate of BLLs ≥10 µg/dL among Men by County of Residence, Michigan 2015-2016

County	Number Reported	Michigan Population Men	Rate[c]	County	Number Reported	Michigan Population Men	Rate[c]
Alcona	0	4,644	-	Lake	0	5,038	-
Alger	0	4,453	-	Lapeer	2	36,405	3
Allegan	10	45,046	11	Leelanau	0	9,091	-
Alpena	0	11,686	-	Lenawee	8	40,325	10
Antrim	2	9,617	10	Livingston	8	76,122	5
Arenac	1	6,441	8	Luce	0	3,236	-
Baraga	1	4,007	12	Mackinac	6	4,739	63
Barry	3	24,092	6	Macomb	43	365,579	6
Bay	4	41,786	5	Manistee	1	10,823	5
Benzie	0	7,202	-	Marquette	2	28,078	4
Berrien	6	60,101	5	Mason	2	11,697	9
Branch	1	17,767	3	Mecosta	0	18,086	-
Calhoun	6	51,683	6	Menominee	2	9,821	10
Cass	2	20,963	5	Midland	3	33,106	5
Charlevoix	1	10,678	5	Missaukee	1	6,093	8
Cheboygan	3	10,760	14	Monroe	16	59,357	13
Chippewa	7	17,694	20	Montcalm	16	26,085	31
Clare	8	12,444	32	Montmorency	0	4,038	-
Clinton	5	30,741	8	Muskegon	15	68,038	11
Crawford	0	5,811	-	Newaygo	1	19,246	3
Delta	1	14,668	3	Oakland	40	487,153	4
Dickinson	4	10,488	19	Oceana	1	10,358	5
Eaton	9	42,987	10	Ogemaw	0	8,668	-
Emmet	2	13,470	7	Ontonagon	0	2,685	-
Genesee	51	154,655	16	Osceola	0	9,266	-
Gladwin	2	10,488	10	Oscoda	0	3,456	-
Gogebic	0	7,176	-	Otsego	2	9,790	10
Grand Traverse	5	37,035	7	Ottawa	5	108,013	2
Gratiot	2	18,189	5	Presque Isle	0	5,489	-
Hillsdale	2	18,362	5	Roscommon	5	10,206	24
Houghton	0	16,461	-	Saginaw	12	74,654	8
Huron	2	12,920	8	Saint Clair	42	63,939	22
Ingham	11	114,270	5	Saint Joseph	5	23,523	11
Ionia	5	27,924	9	Sanilac	12	16,596	36
Iosco	0	10,745	-	Schoolcraft	0	3,345	-
Iron	0	4,774	-	Shiawassee	5	27,325	9
Isabella	0	29,098	-	Tuscola	2	21,708	5
Jackson	8	65,334	6	Van Buren	2	29,357	3
Kalamazoo	13	102,378	6	Washtenaw	14	149,443	5
Kalkaska	0	7,165	-	Wayne	98	653,383	7
Kent	18	244,261	4	Wexford	1	13,026	4
Keweenaw	0	974	-	**Total**	**692[a]**	**3,900,957[b]**	**9**

[a] County was unknown for additional 5 male adults; 87 were out of state residents.

[b] Total number of men in all 83 counties of Michigan age 16+ years; 7/1/2016 County Characteristics Resident Population Estimates, U.S. Census Bureau.

[c] Rate per 100,000 men, age 16+ years.

SOURCE OF EXPOSURE

For 613 (82.2%) individuals with BLLs ≥10 µg/dL, work was the identified source, and for 133 (17.8%) individuals, non-occupational activities were identified as the source of exposure (Table 9). Three sources of exposure predominated for the 133 non-occupationally exposed individuals with BLLs ≥10 µg/dL. Fifty-six (42.1%) individuals were exposed from a hobby related to guns, twenty-seven (20.3%) were exposed due to a retained bullet fragment and twenty-one (15.8%) were presumed exposed to lead in drinking water (eighteen because they lived in Flint Area-Zip Codes 48501-48507 and three lived in Zip Codes: 48532, 48529 and 48602 and their provider presumed water to be the source of exposure) and reported no other source of lead exposure. For an additional 33 individuals, source of exposure is still being investigated. For 68, the source was still unknown after an interview with the individual or review of medical records.

Table 9. Source of Exposure among Adults with BLLs ≥10 µg/dL, Michigan 2015-2016

Exposure Source Description	Number	Percent	Percent Non-Work
Work-Related	613[a]	82.2	
Hobby: Firearms, Reloading, Casting	56	7.5	42.1
Gunshot Wound	27	3.6	20.3
Drinking Water	21	2.8	15.8
Remodeling	11	1.5	8.3
Food, Pottery, Ceramics	9	1.2	6.8
Environment	4	0.5	3.0
Hobby: Unknown	2	0.3	1.5
Other, Not Work	2	0.3	1.5
Hobby: Art	1	0.1	0.7
Total	746[b]	100.0	100.0

[a] Work-Related category includes 7 adults, who were exposed to lead from both Work-Related as well as Non-Work related activities.

[b] For 10 additional adults, source is pending an interview and for 22 we are waiting for receipt of medical records; for 68 additional adults, source was inconclusive and no patient interview was possible.

Table 10 shows the occupational sources of lead for individuals reported in 2015 and 2016. The most frequent reports were on individuals in the manufacturing (37.2%) and construction sector (35.8%).

Table 10. Industry Source of Exposure among Adults with BLLs ≥10 µg/dL, Michigan 2015-2016

Exposure Source --- Industry (SIC Code)[a]	Number	Percent
Construction (15-17)	192	35.8
Painting (17)	*186*	*34.6*
Manufacturing (20-39)	200	37.2
Fabricated and Primary Metals (33-34)	*146*	*27.2*
Transportation and Public Utilities (40-49)	52	9.7
Wholesale and Retail Trade (50-59)	33	6.1
Services (60-89)	51	9.5
Public Administration (91-97)	9	1.7
Justice, Public Order, Safety	*6*	*1.1*
Total	537[b]	100.0

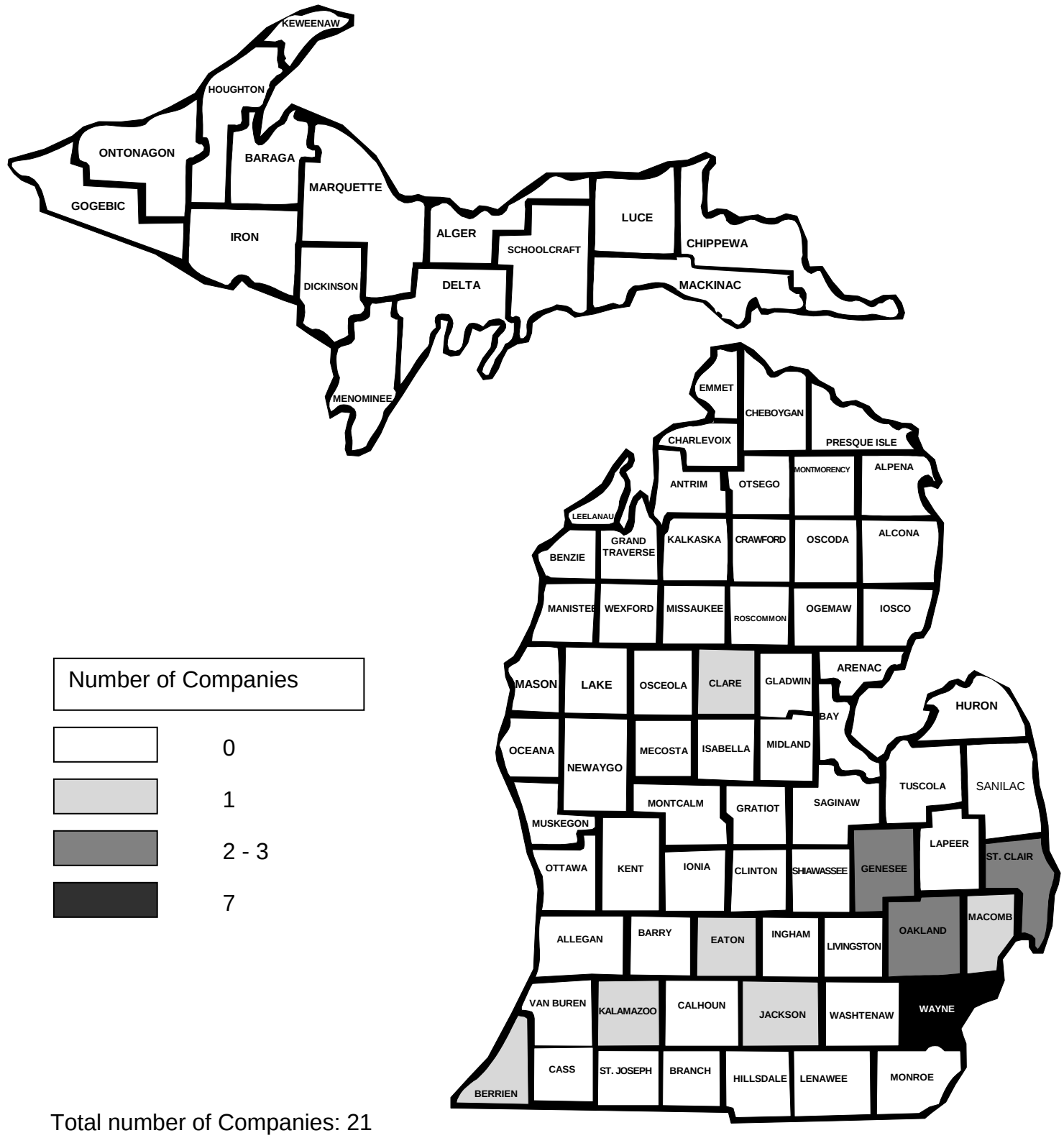
[a] Standard Industrial Classification.
[b] Another 76 were work-related; however, the industry was unknown.

Figure 10 shows the geographic distribution of the twenty-one non-construction companies that reported at least one adult with a BLL of 25 µg/dL or greater in Michigan during 2015 and 2016. In addition, there were four out-of-state companies and two companies for which an address could not be determined due to multiple locations. These 27 companies included primary metal industries, fabricated metal products, an automotive stampings establishment, a storage battery establishment, electric services, a sporting goods store, a repair shop, an industrial machinery and equipment manufacturer, general government, water transportation, local trucking transportation, testing laboratories, engineering services, and firing ranges.

Two hundred and fifteen (35.1%) of the 613 individuals with a blood lead ≥10 µg/dL where exposure occurred at work, and 54 (48.6%) of the 111 individuals with a blood lead ≥25 µg/dL were from these 27 companies.

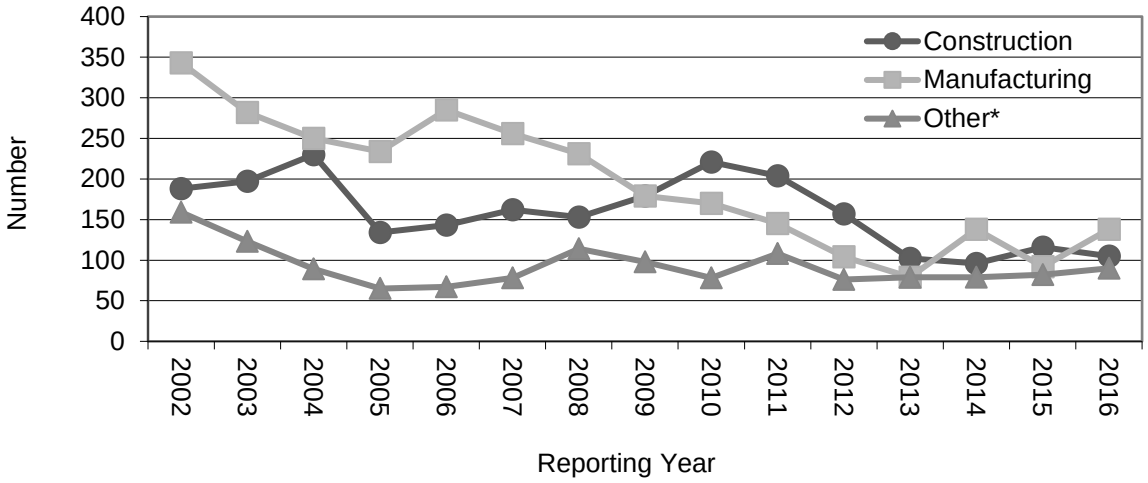
The recent elevated BLLs have generally been decreasing since 2002 in Construction sector and “Other” sector, which includes public utilities, police and public firing ranges (Figure 11). Some of this reduction is due to improvements in workplace controls. However, the Manufacturing sector was a more frequent source of lead exposure in 2014 and 2016 than it was before 2014 and in 2015.

Figure 10. Geographic Distribution of Non-Construction Companies Reporting Adult BLLs ≥25 µg/dL In Michigan, 2015-2016



Total number of Companies: 21

Figure 11. Number of Individuals with BLLs ≥10 µg/dL by Industry Where Exposed to Lead, Michigan 2002-2016



*Includes public utilities, police and retail firing ranges

BLOOD LEAD TESTING IN FLINT

In April of 2014, the City of Flint switched its source of drinking water, resulting in release of lead from water service lines into the drinking water. Although the increased exposure to lead in Flint drinking water began in April 2014, concern about lead exposure did not become widespread until the fall of 2015. The data for 2014 showed a decrease in the overall number of adults tested for lead and the number of elevated blood lead levels from previous years for Genesee County. Part of the reduction in 2014 in the number of elevated blood lead levels in adults in Genesee County was the reduction from three to one in the number of companies in Genesee County where workers were exposed to lead. Beginning in late 2015 and continuing in 2016, the number of adults being tested in Michigan for lead markedly increased, particularly in Flint residents (Figure 12). This was associated with a public health campaign to have everyone in Flint, regardless of age, tested for lead. Table 11 shows the numbers of individuals in the seven Flint zip codes (48501-48507) where most residents were on municipal drinking water, by blood lead level and source of exposure. Source of exposure was identified based on information reported by the laboratory (primarily related to work exposure) and interviews of individuals with elevated blood lead levels.

Figure 12. Adults with Blood Lead Test in the Genesee County and Flint-Area Zip Codes 48501-48507, Michigan 2012-2016

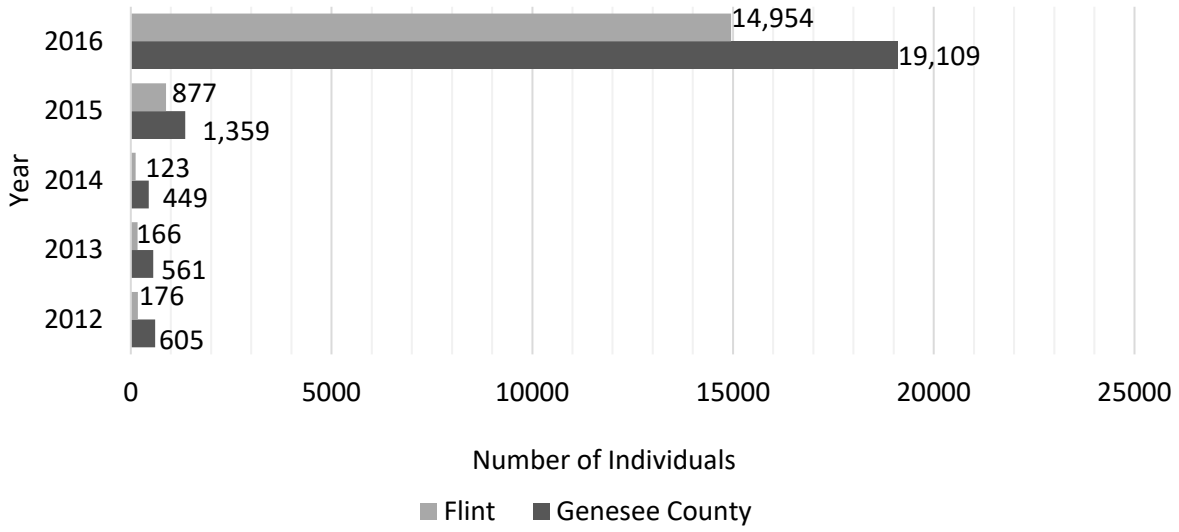


Table 11. Adults with Blood Lead Tests in Flint-Area Zip Codes 48501-48507 Michigan 2015-2016

Blood Lead Level	Number of Individuals	Source of Exposure		
		Work	Non-Work	Unknown
<5 µg/dL	15,439	3	3[a]	15,433
≥5 µg/dL	236	10	75	151
5-9 µg/dL	*201*	*7*	*49[b]*	*145*
10-24 µg/dL	*31*	*3*	*23[c]*	*5*
≥25 µg/dL	*4*	*0*	*3[d]*	*1*
Total	15,675	13	78	15,584

[a] 2: drinking water; 1: other ("take home" exposure)
[b] 33: drinking water; 15: gunshot wound; 1: hobby: firearms
[c] 18: drinking water; 3: gunshot wound; 1: hobby: firearms; 1: remodeling
[d] 2: gunshot wound; 1: unknown, not work

SUMMARY OF INDUSTRIAL HYGIENE INSPECTIONS CONDUCTED FOR BLOOD LEAD LEVELS ≥ 25 µg/dL, 2015-2016

The MIOSHA General Industry Safety and Health Division (GISHD) conducted three inspections and the MIOSHA Construction Safety and Health Division (CSHD) conducted one inspection: a scrap metal recycling establishment, battery refurbisher, a finish carpentry contractor, and an industrial radiator shop. One federal OSHA inspection was conducted at a primary metal manufacturer.

1) Scrap Metal Recycling Establishment

The first GISHD inspection completed in 2015 was initiated because of an employee at a scrap metal recycling facility with a BLL of 25 µg/dL. The facility had three torch cutters working at the time of the inspection. The company also had mobile torch cut crews who were doing demolition work at out-of-state sites at the time of the inspection. The employer was aware that lead paint could be on the metal being cut. The company had a written lead program that included an initial and annual training for lead awareness, and an annual monitoring for lead. The torch cutters worked outside in all weather. They were required to wear ½ faced elastomeric respirators and the employees had annual fit testing and medical respirator evaluation. The employees changed their respirator cartridges every shift. The employees wore fire resistant coveralls; some wore welding leathers, gloves, hard hats and safety glasses with their respiratory protection. All personal protection equipment was stored in lockers at work. All work clothing stayed on site. However, there was no shower room attached to the

locker room.

The company was cited for two serious lead violations and one serious non-lead violation: 1) A written respiratory protection program was not developed and implemented for employees who are required to wear respiratory protection; 2) Surfaces in a workplace were not maintained as free as practicable from accumulations of lead (surfaces in the torcher's trailer and non-ferrous garage had lead contamination); 3) The employer permitted defective or damaged personal protective equipment to be used. (An employee was using welding leathers contaminated with lead. The employee was wearing overalls that were not clean and had burn holes in them).

2) Battery Refurbisher

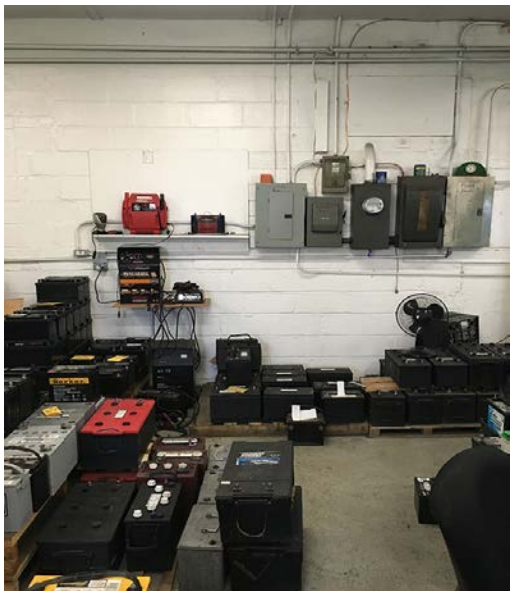
The second GISHD inspection completed in 2016 was initiated because of an employee at a battery refurbisher with a BLL of 71 µg/dL. When the establishment was initially visited by MIOSHA, the employer denied MIOSHA entry. The owner stated that he had no employees and that the individual with elevated BLL was a friend, but never had him do any work for him. MIOSHA obtained a search warrant from the 37th District Court to conduct the enforcement inspection. The company was cited for four lead and 10 non-lead serious violations. The citations included: 1) An employer who has a workplace or work operation subject to lead rules did not determine if an employee might be exposed to lead at or above the action level; 2) Surfaces in a workplace were not maintained as free as practicable from accumulations of lead; 3) Employees were allowed to consume food or beverages in a toilet room or in other areas exposed to a toxic material; 4) Food or beverages were stored in toilet rooms or in an area exposed to a toxic material (employees stored food and beverages near the workstation where batteries were refurbished; lead and sulfuric acid were present at the workstation); 5) Employees who refurbished lead-acid batteries were not informed of the contents of Appendix A and B of the lead standard as required by reference in R 325.51598; 6) An employer did not make a copy of the lead rules and the appendices that would be readily available to all affected employees; 7) There was no written hazard communication program or training on the chemicals in the workplace as required by the standard; 8) The secondary container of sulfuric acid was not labeled with the specific acid type or general information regarding the hazards of the chemical as required by the standard; 9) Safety Data Sheets were not maintained for each chemical on-site (employees used Quick Color Spray Enamel, PB Penetrating Catalyst, and Driver's Choice Auto Protectant to refurbish batteries); 10) The safety data sheet posted in the workplace for "Lead Acid Battery Wet, Filled With Acid" was not the most current version available; 11) The employer did not ensure that each affected employee used appropriate eye or face protection when exposed to eye or face hazards from any of the following: a) Flying particles; b) Molten metal; c) Liquid chemicals; d) Corrosive materials; e) Air contaminants; f) Radiation (Employees were required to clean battery posts with a wire-wheel drill and handled sulfuric acid); 12) The employer did not select and require employees to use appropriate hand protection when employees' hands were exposed to hazards, such as those from any of the following: a) Skin absorption of harmful substances; b) Severe cuts or lacerations; c) Severe abrasions; d) Punctures; e)

Chemical burns; f) Irritating materials; g) Harmful temperature extremes; 13) A suitable eyewash facility was not provided where employees used sulfuric acid; 14) The facility did not have exhaust ventilation. (Highly flammable hydrogen gas could be generated during charging and operation of batteries according to the safety data sheet; there was evidence of smoking inside the shop.)

Picture 1. Stacks of batteries in shop where employees service batteries.

Picture 2. Drink containers and lunch on board with batteries in an employee work area.

Picture 3. Evidence of smoking in the shop (cigarettes on the floor).



Picture 4. Battery chargers on the wall, batteries on pallets.

Picture 5. Sink with batteries around it.

3) Finish Carpentry Contractor

The construction safety and health inspection completed in 2016 was initiated because of an employee at a finish carpentry contractor with BLL of 32 µg/dL. There were 12 employees whose blood lead levels ranged from 10 to 50 µg/dL, with five employees with BLL ≥ 25 µg/dL. The company refinished historic windows installed in homes from the 1880s to 1940s. Most refinishing work occurred at one facility; other refinishing work occurred in the field at the site of the historic homes.

The company was cited for three lead (two serious and one other-than-serious) and two non-lead (other-than-serious) violations: 1) The employer did not determine if any employee may be exposed to lead at or above the action level during manual demolition and scraping of materials coated with lead-containing paint; 2) The employer did not provide appropriate interim protection as described by the lead standard prior to an

employee exposure assessment for employees performing manual demolition of materials coated with lead-containing paint at the site. (Specifically, the employer did not provide appropriate hand washing facilities, implement a respiratory protection program, protective clothing, and timely BLL tests); 3) The employer did not make a copy of the Lead Exposure in Construction standard and its appendices readily available to affected employees while performing manual demolition of materials coated with lead-containing paint; 4) The employer did not develop and maintain, at the site, a written hazard communication program. (Employees were using silica containing paint products at the site); 5) The employer did not train employees on details of the company's hazard communication program, including updated Global Harmonization System elements, signal words and pictograms.

4) Industrial Radiator Repair Shop

The third GISHD inspection completed in 2016 was initiated because of an employee at an industrial radiator shop with a BLL blood lead level of 26 µg/dL.
The facility tears down and repairs used radiators. The shop uses lead-containing solder. The employer provides bi-annual blood lead testing for all employees. Two employees regularly had elevated BLLs.

The company was cited for three serious lead violations: 1) Surfaces in a workplace were not maintained as free as practicable from accumulations of lead. (The analysis of dust wipe samples collected in the facility locker room revealed excessive accumulations of lead both on the exterior surfaces of the grey lockers positioned along the east wall [320 µg/wipe], and the interior surfaces of an employee's personal locker [4,200 µg/wipe]) and exceed the recommendation of 50µg/100 square centimeter (locker used to store food); 2) Routine, periodic (at least once every three months) measurements of the ventilation system, which is used to control potential employee lead exposures during radiator repair operations, have not been performed (ventilation equipment was in need of repair).; 3) Employees exposed to lead while repairing radiators were not informed of the contents of Appendices A & B of the lead standard (Pictures1-3).

Picture 1. Industrial radiator shop.

Picture 2. A locker in which a dust wipe was collected from the bottom. Food was stored in the locker.

Picture 3. Top of the lockers where a dust wipe was collected.

5) Primary Metal Manufacturer

A federal OSHA inspection completed in 2016 in Illinois was initiated because of 20 employees with BLLs ranging from 12 to 58 µg/dL, with eight employees with levels ≥25 µg/dL at a primary metal manufacturer. The company was cited for one serious lead violation and one non-lead violation: 1) All surfaces were not maintained as free as practicable of accumulations of lead. (Wipe samples collected from various surfaces in the employee lunch room, such as the refrigerator handle, the microwave handle and the water fountain spigot indicated the presence of lead ranging from 4.7 to 45.61 µg.); 2) Surfaces were not maintained as free as practicable of accumulations of cadmium. (Wipe samples collected from various surfaces in the employee lunchroom, such as the refrigerator handle and the microwave handle indicated the presence of cadmium ranging from 0.34 to 0.58 µg).

The battery refurbisher company was inspected because the worker had his BLL

measured by a personal physician; the other four companies inspected were identified by an elevated blood lead report collected because of the company provided blood lead monitoring.

CASE NARRATIVES FOR THE TWELVE INDIVIDUALS WITH A BLL ≥50 µg/dL IN 2015-2016

Work-Related (6 Individuals)

- A male in his 20s had an elevated BLL of 61 µg/dL. He was sanding walls painted with lead during the previous four months.
- A male in his 50s, employed at an industrial and commercial machinery and equipment manufacturer based in Michigan, had an elevated BLL of 51 µg/dL. The employee was involved in setting up battery manufacturing equipment in facilities in the United States, China, India and Peru.
- A male in his 20s, employed by a finish carpentry contractor, had an elevated BLL of 50 µg/dL. His work was to sand old painted wooden windows while doing renovation work of old homes.
- A man in his 50s had multiple elevated BLLs, the highest being 71 µg/dL. He was employed at a car battery refurbishing shop. He was cleaning and refurbishing car batteries.
- A man in his 50s, employed at a secondary metal recoverer, had an elevated BLL of 58 µg/dL.
- A man in his 20s, employed at an indoor firing range, had multiple elevated BLLs, the highest being 51 µg/dL.

Non Work-Related (6 Individuals)

- A male in his 20s had multiple elevated BLLs, the highest being 67 µg/dL in 2015. His elevated BLLs were caused by living in an old home while the house was being renovated.
- A male in his 50s had multiple elevated BLLs, the highest being 53 µg/dL in 2015, because of retained bullet fragments.
- A male in his 30s had multiple elevated BLLs, the highest being 59 µg/dL in 2015 and 53 µg/dL in 2016, because of retained bullet fragments. In prior years, his BLL had been as high as 160 µg/dL.

- A female in her 60s had multiple elevated BLLs, the highest being 55 µg/dL in 2016, because of retained bullet fragments. In prior years, her BLL had been as high as 155 µg/dL.
- A male in his 70s had multiple elevated BLLs, the highest being 89 in 2016. His elevated BLLs were caused by doing a renovation work in an old farmhouse.
- A female in her 20s had multiple elevated BLLs, the highest being 106 µg/dL in July 2016. Her elevated BLLs were caused by microwaving water and drinking coffee in pottery made in Mexico with a lead glaze.

NINETEEN YEARS OF INTERVIEWS OF ADULTS WITH BLLs ≥10 µg/dL REGARDING THEIR CHILDREN'S POTENTIAL EXPOSURE TO "TAKE HOME" LEAD

Between October 15, 1997, and December 31, 2011, there were 2,016 questionnaires completed over the telephone with adults with BLLs ≥10 µg/dL. The results of these interviews can be found in the 2011 Annual Report on Blood Lead Levels on Adults in Michigan, May 24, 2013 at: (http://www.oem.msu.edu/userfiles/file/Annual%20Reports/Lead/2011LeadAnnualReport.pdf). Table 17, in that report, indicates the number of households with children (six or under) potentially exposed to take home lead from adults with BLLs ≥10 µg/dL. That table has been updated with the results of thirty-seven interviews completed between 2012 and 2016 where the person interviewed had a child under six in the household (Table 12).

Twenty-five percent of the households where an adult had an elevated lead level had children age 6 and younger living or spending time in the home (Table 12). Children from only 158 (34.2%) of these 538 households were tested for blood lead. Among the 158 households where the child's blood test results were reported, 52 (35.1%) reported a child with an elevated blood lead level (≥10 µg/dL). Contact information for individuals reporting young children in their household who had not been tested for lead was forwarded to MDHHS so that a letter could be sent encouraging adults in those households to have the children tested for lead.

Table 12. Number and Percent of Households with Children (6 or under) Potentially Exposed to Take Home Lead from Adults with BLLs ≥10 µg/dL (based on highest reported BLL) Interviewed 10/15/1997 to 12/31/2016, by Highest Blood Lead of Adult

Description of Households	10-24 µg/dL		25-29 µg/dL		30-39 µg/dL		40-49 µg/dL		50-59 µg/dL		≥ 60 µg/dL		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Households with Children Living or Spending Time	309	23.5	80	27.2	99	27.6	32	27.8	11	26.2	7	26.9	538	25.0[a]
Households with Children Tested for Lead	95	36.7	20	28.6	22	24.7	14	51.9	4	36.4	3	50.0	158	34.2[b]
Households Where Children had Elevated Lead	28	31.5	4	22.2	9	37.5	8	61.5	1	33.3	2	66.6	52	35.1[c]

[a]Among individuals within blood lead category, percentage of their households with children living or spending time in house. n=2,151
[b]Among individuals within blood lead category, percentage of "Households with Children Living/Spending Time", where the children were tested for lead. Because of missing data, the denominator may be less than the number "Households w/ Children Living/Spending Time" in the first row. n=462
[c]Among individuals within blood lead category, percentage of "Households w/Children Living/Spending Time ", where " Children Tested for Lead", had blood lead levels ≥ 10 µg/dL. Because of missing data, the denominator may be less than the "Children Tested for Lead" in the second row. n=148

DISCUSSION

An individual may have a blood lead test performed as part of an employer medical-screening program or as part of a diagnostic evaluation by their personal physician. Whatever the reason for testing, the results are then sent by the testing laboratories to the MDHHS as required by law. If the individual tested is 16 years old, the report is then forwarded to MSU and maintained in the ABLES program lead registry. Individuals with a blood lead level of 25 µg/dL or greater, individuals with BLLs of 10-24 µg/dL, where lead exposure source is not already known, and Flint residents with a blood lead level of 5 µg/dL or greater are contacted by mail and then contacted by a trained interviewer for a voluntary telephone interview. The interview includes detailed demographic information, exposure history and the presence and nature of lead-related symptoms. When an individual with a blood lead value of 25 µg/dL or greater is occupationally exposed at a company that has not had a recent MIOSHA inspection, an enforcement inspection is conducted by MIOSHA to assess that company's compliance with the lead standard.

In 2015 through 2016, there were 846 adults with BLLs ≥10 µg/dL and another 1,793 with a BLL 5-9 µg/dl. Among individuals with a BLL ≥10 µg/dL, approximately 92% were men. Their mean age was 45.2. They were predominately white (76.7%) and lived in a

band of counties stretching across the southern part of the state from Kalamazoo to St. Clair. The source of exposure to lead was predominately their work (82.2%). The most common work exposures occurred during demolition of lead painted metal structures and abrasive blasting to remove paint, during the fabricating of non-ferrous metal parts and metal products and while working in a firing range.

In 2015 through 2016, twelve Michigan adults were reported with BLLs greater than or equal to 50 µg/dL, the maximum blood lead level allowed in the workplace. Six of the twelve adults was exposed to lead exclusively at work (sanding -walls, windows, setting up machinery that makes batteries, cleaning and refurbishing car batteries, secondary metal smelting, gun range). There were three individuals with non-work exposure to lead who had retained bullet fragments, two individuals exposed to lead through home renovation and one because of using pottery from Mexico made with a lead glaze.

Lead exposure remains an important public health concern in the U.S. Environmental Protection Agency (EPA) regulations, which required the removal of lead from commercial products such as gasoline, house paint and solder in plumbing pipes and food cans. As a result, exposure to lead has been greatly reduced in the general population. Average BLLs in the general population have dropped from 15 µg/dL in the 1970s to the current 0.973 µg/dL (2).

The problem of lead in drinking water is not unique to Flint. Lead is a potential problem in many urban areas with aging water infrastructure. What made the issue so dramatic in Flint was the change in water source and lack of provision to deal with the corrosiveness of the new water source. This abrupt change in water source allowed for the recognition of changes in blood lead, which would normally not be identified with the ongoing slow deterioration of water infrastructure. As a society, we have reduced human lead exposure by removal of lead from gasoline and consumer products, and initiated programs to remove lead paint from housing built before 1978. It is likely that lead in drinking water from aging water infrastructures will become an increasingly high percentage of lead exposure to the general population. This will be particularly true for young infants ingesting formula made with tap water, who do not have the potential to be exposed to lead dust on surfaces or ingest dust-containing lead from paint chips because they are not yet crawling.

Occupational exposure has not declined as much as environmental lead exposure. Data from 28 state lead surveillance systems shows that nationally, approximately 95% of adult elevated lead exposure is work-related (1). Occupational Safety and Health Administration (OSHA) lead standards, established in 1978 for general industry and in 1993 for construction, set the level for removal of a worker from lead exposure in general industry at 60 µg/dL or two consecutive values above 50 µg/dL and construction at 50 µg/dL. These levels were established when general population levels from environmental exposure were much higher than they are today. The Michigan OSHA program has initiated rule-making procedures to modernize the occupational lead standard. Similar efforts are underway in two other state plan states, California and Washington.

Over thirty years of lead toxicity research has demonstrated that lead exposure at levels previously thought to be of little concern can result in an increased risk of adverse chronic health effects, especially if the exposure is maintained for many years, thereby resulting in a progressively larger cumulative dose (1,7-9). Levels as low as 5 µg/dL have been associated with adverse cardiovascular and neurologic health effects in adults (7,10).

Both the International Agency for Cancer (IARC) and the National Toxicology Program have classified lead to be a probable human carcinogen (11,12), primarily based on findings for lung and stomach cancer, with brain and kidney cancer also being elevated in some studies. Others studies show that lead exposure increases blood pressure in adults (1), making both mortality from stroke and heart disease outcomes of interest. High lead exposure is known to cause non-malignant kidney disease (13), but it is not known if lower levels contribute to this outcome.

Michigan occupations with lead exposure include abrasive blasting to remove lead paint from outdoor metal structures such as bridges, overpasses or water towers; casting brass or bronze fixtures; fabricating metal products; or exposure to lead fumes or dust from firing guns or retrieval of spent bullets at firing ranges. While the use of lead in non-battery products has declined in the U.S., the use of lead worldwide continues to grow, especially in battery applications. Recycling the growing amount of “e-waste” created by discarded electronic and lead battery consumer products and the increased demand for raw metals and specifically recycled lead worldwide puts a new group of workers at risk to significant exposure to lead.

Since 2002, the Michigan ABLES project has sent letters to laboratories, which provide blood lead analysis for Michigan residents, recommending the laboratories lower their upper limit of normal blood lead levels to correspond with current medical knowledge of the adverse health effects of lead. All but one of the laboratories providing blood lead analyses in Michigan has lowered the upper limit of normal to 10 µg/dL. Given the recent decision by the CDC to consider blood leads in children of 5 µg/dL or greater to be elevated and the increasing scientific knowledge about the toxicity of lead at these low levels to adults, laboratory reference levels should indicate an upper limit of normal of 5 µg/dL for all ages. Recommendations for medical management on lead exposed individuals begin at 5 µg/dL and interpretative language for the healthcare providers who ordered the blood lead needs to be compatible with these recommendations since laboratory reports are often their main source of information (5) (See Appendix D). The February 2015 update of the Fourth Annual CDC Report shows that blood leads in the general population are continuing to fall and the 95th confidence limit for the upper limit of normal in 2011-2012 was 3.36 µg/dL (2.98-3.93) (2).

Although the major source of lead exposure to children is living in housing built before 1978 that has deteriorating lead paint, another source is adults working in lead occupations who bring lead home on their shoes or clothes and expose their spouse and children. MIOSHA regulations require employers to wash work clothes, and provide

showering facilities and clean and dirty change rooms for lead-exposed employees to reduce “take-home” exposure to their families. It is important that workers who have children six years or younger who live in or frequently visit their home assure that these children are tested for lead. Unfortunately, this is not happening; only one in three families with adults exposed to lead at work report that their young children are tested for lead. When these children are tested, 35.1% are found to have an elevated blood lead level (Table 12). This is a much higher percentage of elevated blood lead levels than typically found among children less than six years of age tested for blood lead in the state (3.4%) (14). Children of lead-exposed workers are a high risk group for having an elevated blood lead and efforts to increase lead testing in these children should be expanded.

In its nineteenth year of operation, the surveillance system for lead continues to prove successful in identifying adults with elevated lead levels and sources of exposure that could be remediated to reduce exposures in Michigan. There has been a reduction in the number of individuals with elevated blood lead levels from occupational exposures; however, there was an increase in the number of individuals with elevated BLLs from non-work exposures in 2016 (Figures 2-4).

Continued outreach is planned to the medical community to promote recognition and management of potential lead-related medical problems in both individuals and their young family members. The administrative procedure is now underway to update workplace lead standards in Michigan. Adoption of new regulations will not only reduce the major source of lead exposure to adults, but will also reduce lead exposure to workers’ children because of reduction in lead taken home on the clothes and footwear of individuals who work with lead. Ongoing surveillance in future years will continue to target and evaluate intervention activity to assure a continued downward reduction in blood lead levels and exposure to lead.

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APPENDICES

Appendix A. Elevated Blood Lead Levels Among Employed Adults – United States, 1994 – 2013. *Morbidity and Mortality Weekly Report* October 14, 2016

Appendix B. Summary of Michigan's Lead Standards

Appendix C. Reference Blood Lead Levels (BLL) for Adults in the U.S.

Appendix D. Management Guidelines for Blood Lead Levels in Adults

Appendix A

Elevated Blood Lead Levels Among Employed Adults – United States, 1994 – 2013. *Morbidity and Mortality Weekly Report*
October 14, 2016

Elevated Blood Lead Levels Among Employed Adults — United States, 1994–2013

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Preface

CDC's National Institute for Occupational Safety and Health (NIOSH) and state health departments collect data on laboratory-reported adult blood lead levels (BLLs). This report presents data on elevated BLLs among employed adults (defined as persons aged ≥16 years) in the United States for 1994–2013. This report is a part of the *Summary of Notifiable Noninfectious Conditions and Disease Outbreaks — United States*, which encompasses various surveillance years but is being published in 2016 (*1*). The *Summary of Notifiable Noninfectious Conditions and Disease Outbreaks* appears in the same volume of the Morbidity Mortality Weekly Report (*MMWR)* as the annual *Summary of Notifiable Infectious Diseases* (*2*).

Background

Since 1987, NIOSH and state health departments have maintained the Adult Blood Lead Epidemiology and Surveillance (ABLES) Program, a state-based surveillance program of laboratory-reported adult BLLs (*3*). The BLL is an often-used estimate of recent external exposure to lead (*4*,*5*). This report summarizes data on elevated BLLs among employed adults during January 1, 1994–December 31, 2013.

Information is provided by geographic division and reporting state, for "all cases" reported by a state (these include cases among adult residents in the reporting state plus cases identified by the reporting state but occurring among persons who reside in another state) and "state-residents" only, by exposure source, for BLLs ≥10 μg/dL (definition of elevated BLL from 2009 until 2014) (*3*,*6*–*8*), and for BLLs ≥25 μg/dL (previous definition of elevated BLL) (*9*). The current case definition (BLL ≥5 μg/dL) was adopted in 2015 and became effective in 2016, on the basis of mounting evidence for adverse health outcomes among adults with BLLs between 5 μg/dL and 25 μg/dL (*4*,*5*). State prevalence rates of elevated BLLs (≥10 μg/dL) for 2013 are categorized into two groups (above or below the national prevalence rate) (Figure 1). Trends of national prevalence rates of BLLs ≥10 μg/dL and BLLs ≥25 μg/dL from 1994 to 2013 are provided (Figure 2).

ABLES is the only program conducting nationwide adult lead exposure surveillance. It has provided the occupational safety and health community with essential information for setting research and intervention priorities. ABLES' impact is achieved through its longstanding strategic partnerships with state ABLES programs, federal agencies, and worker-affiliated organizations. For example, in 2008, the Occupational Safety and Health Administration (OSHA) updated its National Lead Emphasis Program to reduce occupational lead exposure by targeting unsafe conditions and high-hazard industries (*10*). To accomplish this objective, OSHA used national ABLES data to identify industries whose employees exhibit high BLLs. OSHA has agreements with state ABLES programs to use their lead exposure data to target workplace inspections.

Although federal funding for state ABLES programs was discontinued in September 2013, a total of 30 states continue to collaborate with NIOSH (down from a peak of 41 states) to provide data. In August 2015, funding to support adult BLL surveillance was resumed at a reduced level. To sustain lead exposure surveillance and prevention activities, state ABLES programs share resources with two other CDC programs: the Childhood Lead Poisoning Prevention Program and the Environmental Public Health Tracking Program. Since September 2013, NIOSH has continued to provide technical assistance to states with adult blood lead surveillance programs and maintains the ABLES website for reporting ABLES findings.

The BLL is a direct index of a worker's exposure to lead as well as an indication of the potential for adverse effects from that exposure (*4*,*5*). The half-life of lead in blood is approximately 40 days in males (*11*), so the BLL is an estimate primarily of recent exposure to lead. Because lead accumulates in bone and BLL is in equilibrium with bone lead, the BLL might be elevated in some persons who have not had recent exposure to lead. Because this equilibrium can lead to persistent BLL elevations, the public health burden of elevated BLLs in adults is measured as prevalence. In contrast, the public health burden of elevated BLLs in children aged <3 years is measured as incidence because these young children have little lead

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storage in their bones at birth and thus their early childhood blood lead tests reflect recent exposures.

Over the past several decades in the United States, a marked reduction has occurred in environmental sources of lead, and protection from occupational lead exposure has improved. As a result, there is an overall decreasing trend in the mean BLL and in the prevalence of elevated BLLs among adults. During 2011–2012, the mean BLL in adults in the United States was 1.09 μg/dL (*12*). Nonetheless, lead exposures among adults continue to occur at unacceptable levels (*3*).

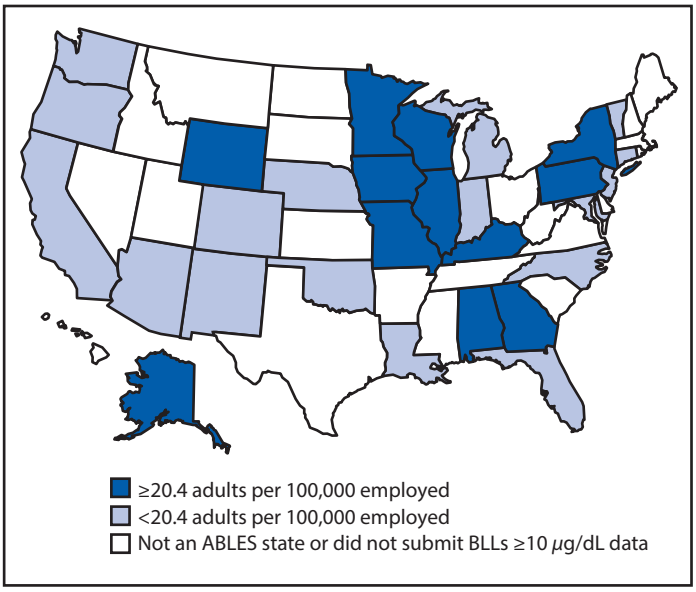
Data Sources

The ABLES program is a state-based surveillance system of adult BLLs. The number of cases (numerator) is currently provided by ABLES programs in 30 states (29 states provided data on BLLs ≥10 μg/dL). The number of employed adults (denominator) is obtained from the Local Area Unemployment Statistics (LAUS), Bureau of Labor Statistics, in the U.S. Department of Labor (http://www.bls.gov/data). A direct link to annual averages of states' employment status of the civilian noninstitutionalized population is available (http://www.bls.gov/lau/staadata.txt). NIOSH consolidates data from reporting state ABLES programs, conducts data quality control, analyzes the data, and disseminates the findings among stakeholders. State ABLES programs 1) collect data on adult BLLs from laboratories and physicians through mandatory reporting; 2) assign unique identifiers to each adult to account for multiple BLL records per person, protect individual privacy, and permit longitudinal analyses; 3) follow-up on adults with BLLs ≥10 or ≥25 μg/dL with laboratories, health care providers, employers, or workers to ensure completeness of information (e.g., the industry in which the adult is employed and whether the exposure source is occupational, nonoccupational, or both); 4) provide guidance and information to workers and employers to prevent lead exposures; and 5) submit data annually to NIOSH. Most ABLES states submit data on all BLLs (both occupational and nonoccupational) to NIOSH, including records from adults whose BLLs fall below the state mandatory reporting requirement.

Interpreting Data

The primary measure of adult lead exposure in the United States is the national prevalence rate of elevated BLLs among employed adults. This measure is provided by the ABLES program and can be used to estimate the magnitude and monitor trends of lead exposures and to target areas requiring further investigation or interventions.

FIGURE 1. Prevalence rate* of adults with blood lead levels (BLLs) ≥10 μg/dL, by state — State Adult Blood Lead Epidemiology and Surveillance (ABLES) programs, United States, 2013†



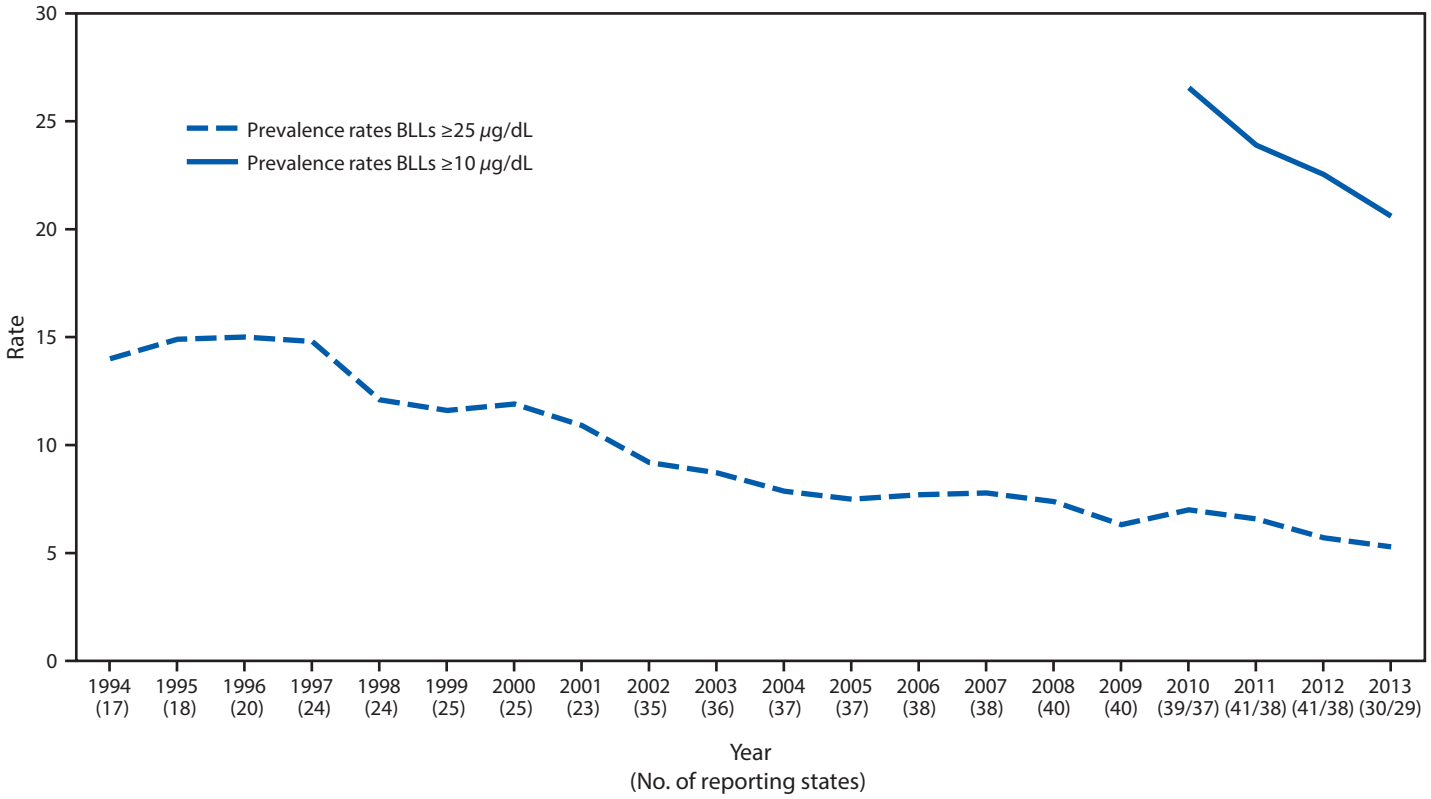
* Rate per 100,000 employed adults aged ≥16 years. State-resident prevalence rate might be lower for some states. Data from the Adult Blood Epidemiology and Surveillance (ABLES) Program, National Institute for Occupational Safety and Health (NIOSH/CDC). Denominators for 2013 extracted from 2015 U.S. Department of Labor, Bureau of Labor Statistics, Local Area Unemployment Statistics program (http://www.bls.gov/lau/staadata.txt).

† The national rate in 2013 was 20.4 cases per 100,000 employed adults aged ≥16 years. A total of 30 states submitted data in 2013: Alabama, Alaska, Arizona, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Vermont, Washington, Wisconsin, and Wyoming. Massachusetts provided data for BLLs ≥25 μg/dL. In 2013, Missouri (111.8) and Iowa (53.7) reported the highest prevalence rates of elevated blood lead levels.

Efforts to reduce lead exposures have resulted in considerable progress in reducing the prevalence of elevated BLLs. However, many adults in the United States continue to have BLLs known to be associated with acute and chronic adverse effects in multiple organ systems ranging from subclinical changes in function to symptomatic intoxication. These include neurologic, cardiovascular, reproductive, hematologic, and kidney adverse effects. The risks for adverse chronic health effects are even higher if the exposure is maintained for many years (*4*,*5*). Current research has found decreased renal function associated with BLLs at ≤5 μg/dL and increased risk of hypertension and essential tremor at BLLs <10 μg/dL (*13*).

Prevalence rates of adults with BLLs ≥25 μg/dL are available since 1994. Beginning in 2002, state ABLES programs reported individual BLL laboratory test results and state of residence. Formerly, state resident and nonresident data could not be separated. When an adult has multiple blood lead tests in a given year, only the highest BLL for that adult in that year is counted. Prevalence rates of BLLs ≥10 μg/dL are available for

FIGURE 2. National prevalence rate* of reported cases of elevated blood lead levels,† by year — State Adult Blood Epidemiology and Surveillance Programs, United States, 1994–2013§



Abbreviation: BLL = blood lead level.

* Per 100,000 employed adults aged ≥16 years. Denominator data extracted from 2015 U.S. Department of Labor, Bureau of labor Statistics Local Area Unemployment Statistics (LAUS) program (http://www.bls.gov/lau/staadata.txt).

† Since 2009, the case definition for an elevated blood lead level is a BLL ≥10 μg/dL. For historical comparisons, prevalence rates at the previous case definition (BLL ≥25 μg/dL) are provided.

§ A total of 30 states submitted data in 2013 (down from 41 states in 2012): Alabama, Alaska, Arizona, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Vermont, Washington, Wisconsin, Wyoming. Massachusetts provided data for BLLs ≥25 μg/dL. For 2013, the first number is the number of states reporting BLLs ≥25 μg/dL (i.e., 30 states in 2013), and the second number is the number of states reporting BLLs ≥10 μg/dL (i.e., 29 states in 2013).

2010 forward. Prevalence rates of BLLs ≥25 μg/dL are a subset of prevalence rates of BLLs ≥10 μg/dL. In the United States, most lead exposures among adults are occupational (*9*). A total of 29 states submitted work-relatedness information in 2013. Prevalence rate differences across states could reflect improved compliance with required OSHA monitoring in some states.

These counts and rates of elevated BLLs must be considered minimum estimates of the actual magnitude of the problem of lead exposures in the United States. This is for multiple reasons:

- not all states participate in the ABLES program;
- not all employers provide BLL testing to lead-exposed workers as required by OSHA regulations;
- not all nonoccupationally exposed adults are tested; and
- some laboratories might not report all tests as required by state laws or regulations.

For specific explanations, interpretation, and possible updates on data for any individual state, the state ABLES program investigator should be contacted directly. Contact information is available at http://www.cdc.gov/niosh/topics/ABLES/state.html.

Methods for Identifying Elevated BLLs Among Employed Adults

Beginning in 2016, a nationally reportable case of an employed adult with an elevated BLL is defined as a case in an employed person aged ≥16 years at the time of blood collection with a venous blood lead level ≥5 μg/dL of whole blood. The standardized diagnostic test is the BLL test using a venous blood sample. All participating state health departments have a requirement for laboratories and/or health care providers

to report laboratory blood lead results to the state health department. However, this requirement varies among ABLES states, ranging from the reporting of all BLLs to reporting only BLLs ≥40 μg/dL (*3*). The ABLES program ultimately aims to establish a national database for all BLL tests among adults and encourages all states to share information with NIOSH.

Publication Criteria

Cases meet the publication criteria if the employed adult (aged ≥ 16 years) had a venous BLL ≥25 μg/dL during 1994–2013 or a venous BLL ≥10 μg/dL during 2010–2013. When an adult had multiple blood lead tests in a given year, only the highest BLL for that adult in that year was counted. Prevalence rates of BLLs ≥25 μg/dL are a subset of prevalence rates of BLLs ≥10 μg/dL and are included for historic comparison.

Highlights

In 2013, the prevalence rate of BLLs ≥10 μg/dL was 20.4 adults per 100,000 employed population, calculated from 29 reporting states. In 2013, a total of 30 states submitted data on 5,504 adults with BLLs ≥25 μg/dL, and 29 states submitted data on 20,880 adults with BLLs ≥10μg/dL (Table 1). A total of 23 states submitted individual level data, and seven states submitted count data only. Overall, the national prevalence rate of BLLs ≥10 μg/dL declined from 26.6 adults per 100,000 employed in 2010 (among 37 states) to 20.4 in 2013 (among 29 reporting states). In 2013, of the 29 reporting states, 12 had prevalence rates of BLLs ≥10μg/dL equal to or above the national prevalence rate (20.4/100,000) (Figure 1). The national prevalence rate of BLLs ≥25 μg/dL among state residents and nonresidents declined from 14.0 adults per 100,000 employed in 1994 (among 17 states) to 5.2 in 2013 (among 30 states).

Historically, in the United States, most lead exposures among adults have been occupational. In 2013, a total of 29 states submitted data on 5,491 adults with BLLs ≥25 μg/dL of which 944 (17.2%) had no known exposure history (Table 2). Among the 4,547 adults with known exposure, 93.7% had occupational exposure, ranging from 42.9% to 100% among reporting states. Individual level data on 2,313 occupational cases with BLLs ≥25 μg/dL were available from 22 states. The majority of these adults were employed in four main industry sectors: manufacturing (n = 1,227 [53.1%]), construction (n = 468 [20.2%]), services (n = 194 [8.4%]), and mining (n = 182 [7.9%]). Within manufacturing, the majority of cases (n = 878; 71.6%) were among workers employed in storage battery manufacturing (North American Industry Classification System [NAICS] 33591), alumina and aluminum production and processing (NAICS 33131), and nonferrous metal (except copper and aluminum) rolling, drawing, extruding, and alloying (NAICS 33149) industries. Within construction, the majority of cases (n = 329 [70.3%]) were among workers employed in painting and wall covering contractors (NAICS 23832); highway, street, and bridge construction (NAICS 23731); and residential building construction (NAICS 23611) industries. Within the services sector, the majority of cases (n = 128 [66%]) were among workers employed in remediation services (NAICS 56291); all other amusement and recreation industries (NAICS 71399); automotive, mechanical, and electrical repair and maintenance (NAICS 81111); and fitness and recreational sports centers (NAICS 71394). Copper, nickel, lead, and zinc mining (NAICS 21223) accounted for 98.9% of the mining cases.

TABLE 1. Reported numbers of cases and prevalence rates of adults* with blood lead levels ≥10 μg/dL and blood lead levels ≥25 μg/dL, by geographic division and area — state Adult Blood Lead Epidemiology and Surveillance programs, United States, 2013†

Division/State	No. of employed state-resident adults (in 1,000s)	Blood lead levels ≥10 μg/dL				Blood lead levels ≥25 μg/dL§			
		All cases¶		State residents**		All cases		State residents	
		No.	(Rate)	No.	(Rate)	No.	(Rate)	No.	(Rate)
Total	**105,474**	**20,880**	**(20.4)**	**19,603**	**(19.2)**	**5,504**	**(5.2)**	**5,183**	**(4.9)**
New England									
Connecticut	1,724	331	(19.2)	313	(18.2)	62	(3.6)	61	(3.5)
Massachusetts	3,272	—††	(—)	—	(—)	126	(3.9)	105	(3.2)
Vermont	336	47	(14.0)	47	(14.0)	12	(3.6)	12	(3.6)
Mid Atlantic									
New Jersey	4,164	832	(20.0)	832	(20.0)	158	(3.8)	158	(3.8)
New York	8,891	1,873	(21.1)	1,731	(19.5)	295	(3.3)	270	(3.0)
Pennsylvania	5,964	2,928	(49.1)	2,915	(48.9)	1,533	(25.7)	1,527	(25.6)
East North Central									
Illinois	5,961	1,279	(21.5)	1,253	(21.0)	283	(4.7)	279	(4.7)
Indiana	2,947	596	(20.2)	596	(20.2)	113	(3.8)	113	(3.8)
Michigan	4,306	596	(13.8)	595	(13.8)	108	(2.5)	108	(2.5)
Wisconsin	2,877	687	(23.9)	686	(23.8)	105	(3.7)	105	(3.7)
West North Central									
Iowa	1,594	856	(53.7)	856	(53.7)	202	(12.7)	202	(12.7)
Minnesota	2,819	598	(21.2)	598	(21.2)	107	(3.8)	107	(3.8)
Missouri	2,814	3,145	(111.8)	2,835	(100.8)	690	(24.5)	613	(21.8)
Nebraska	983	195	(19.8)	195	(19.8)	32	(3.3)	32	(3.3)
South Atlantic									
Florida	8,783	888	(10.1)	863	(9.8)	270	(3.1)	266	(3.0)
Georgia	4,368	898	(20.6)	897	(20.5)	237	(5.4)	237	(5.4)
Maryland	2,917	275	(9.4)	234	(8.0)	75	(2.6)	62	(2.1)
North Carolina	4,310	219	(5.1)	218	(5.1)	99	(2.3)	99	(2.3)
East South Central									
Alabama	2,012	928	(46.1)	548	(27.2)	433	(21.5)	299	(14.9)
Kentucky	1,892	478	(25.3)	468	(24.7)	94	(5.0)	92	(4.9)
West South Central									
Louisiana	1,965	380	(19.3)	380	(19.3)	92	(4.7)	92	(4.7)
Oklahoma	1,707	144	(8.4)	121	(7.1)	29	(1.7)	27	(1.6)
Mountain									
Arizona§§	2,804	178	(6.3)	178	(6.3)	20	(0.7)	20	(0.7)
Colorado	2,591	103	(4.0)	41	(1.6)	29	(1.1)	15	(0.6)
New Mexico	859	48	(5.6)	48	(5.6)	13	(1.5)	13	(1.5)
Wyoming	292	66	(22.6)	66	(22.6)	12	(4.1)	12	(4.1)
Pacific									
Alaska	340	123	(36.1)	62	(18.2)	8	(2.4)	6	(1.8)
California	17,003	1,825	(10.7)	1,790	(10.5)	192	(1.1)	191	(1.1)
Oregon	1,761	92	(5.2)	79	(4.5)	12	(0.7)	9	(0.5)
Washington	3,217	272	(8.5)	158	(4.9)	63	(2.0)	51	(1.6)

* An employed person aged ≥16 years at the time of blood collection. When an adult had multiple blood lead tests in a given year, only the highest blood lead level for that adult in that year was counted. Rate per 100,000 employed adults. Data from the Adult Blood Epidemiology and Surveillance (ABLES) Program, National Institute for Occupational Safety and Health (NIOSH/CDC). Denominators extracted from 2015 U.S. Department of Labor, Bureau of Labor Statistics, Local Area Unemployment Statistics (LAUS) program (http://www.bls.gov/lau/staadata.txt).

† A total of 30 states participated in the ABLES Program in 2013.

§ The numbers and rates of adults with BLLs ≥25 μg/dL are subsets of the numbers and rates of adults with BLLs ≥10 μg/dL.

¶ All cases reported by a state. These include cases among adult residents in the reporting state plus cases identified by the reporting state but who reside in another state.

** Adults residing in the reporting state.

†† 10–15 μg/dL BLL data were not available.

§§ Data from Arizona were available only for January to August 2013.

TABLE 2. Reported numbers of adults* with blood lead levels ≥25 *μg*/dL, by exposure source and area — state Adult Blood Lead Epidemiology and Surveillance programs, United States, 2013†

	Occupational§		Nonoccupational		Unknown		Total
Division/State	No.	(%)	No.	(%)	No.	(%)	No.
Total	**4,262**	**(77.6)**	**285**	**(5.2)**	**944**	**(17.2)**	**5,491**
New England							
Connecticut	37	(59.7)	23	(37.1)	2	(3.2)	**62**
Massachusetts	71	(56.3)	24	(19.0)	31	(24.6)	**126**
Vermont	3	(25.0)	4	(33.3)	5	(41.7)	**12**
Mid Atlantic							
New Jersey	105	(66.5)	—¶	(—)	53	(33.5)	**158**
New York	191	(64.7)	78	(26.4)	26	(8.8)	**295**
Pennsylvania	1,449	(94.5)	—	(—)	84	(5.5)	**1,533**
East North Central							
Illinois	177	(62.5)	14	(4.9)	92	(32.5)	**283**
Indiana	67	(59.3)	—	(—)	46	(40.7)	**113**
Michigan	70	(64.8)	28	(25.9)	10	(9.3)	**108**
Wisconsin	88	(83.8)	9	(8.6)	8	(7.6)	**105**
West North Central							
Iowa	200	(99.0)	2	(1.0)	—	(—)	**202**
Minnesota	92	(86.0)	3	(2.8)	12	(11.2)	**107**
Missouri	682	(98.8)	8	(1.2)	—	(—)	**690**
Nebraska	25	(78.1)	2	(6.3)	5	(15.6)	**32**
South Atlantic							
Florida	82	(30.4)	11	(4.1)	177	(65.6)	**270**
Georgia	100	(42.2)	—	(—)	137	(57.8)	**237**
Maryland	57	(76.0)	4	(5.3)	14	(18.7)	**75**
North Carolina	89	(89.9)	8	(8.1)	2	(2.0)	**99**
East South Central							
Alabama	353	(81.5)	—	(—)	80	(18.5)	**433**
Kentucky	—	(—)	—	(—)	94	(100.0)	**94**
West South Central							
Louisiana	78	(92.9)	5	(6.0)	1	(1.2)	**84**
Oklahoma	7	(24.1)	2	(6.9)	20	(69.0)	**29**
Mountain							
Arizona	12	(80.0)	3	(20.0)	–	(—)	**15**
Colorado	4	(13.8)	3	(10.3)	22	(75.9)	**29**
New Mexico	4	(30.8)	3	(23.1)	6	(46.2)	**13**
Wyoming	12	(100.0)	—	(—)	–	(—)	**12**
Pacific							
Alaska	5	(62.5)	—	(—)	3	(37.5)	**8**
California	146	(76.0)	45	(23.4)	1	(0.5)	**192**
Oregon	7	(58.3)	1	(8.3)	4	(33.3)	**12**
Washington	49	(77.8)	5	(7.9)	9	(14.3)	**63**

* An employed person aged ≥16 years at the time of blood collection. When an adult had multiple blood lead tests in a given year, only the highest blood lead level for that adult in that year was counted.

† Among the 30 reporting states, 29 states submitted data on exposure source in 2013. These data include adult residents in the state and residents of other states reported by the state ABLES programs.

§ Includes 23 cases coded with both occupational and nonoccupational exposure source.

¶ No cases were reported.

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Appendix B

Summary of Michigan's Lead Standards

SUMMARY OF MICHIGAN'S OCCUPATIONAL LEAD STANDARDS

In 1981, under the authority of the Michigan Occupational Safety and Health Act (MIOSHA), Michigan promulgated a comprehensive standard to protect workers exposed to lead in general industry (i.e., R325.51901 - 325.51958). That standard was most recently amended in October, 2000. In October 1993, MIOSHA adopted by reference the federal Occupational Safety and Health Administration's (OSHA) Lead Standard for Construction (i.e., 29 CFR 1926.62). That standard was most recently amended October 18, 1999. Both the MIOSHA Lead Exposure in Construction Standard (Part 603) and the Lead Exposure in General Industry Standard (Part 310) establish an "action level" (30 micrograms of lead per cubic meter of air [ug/m^3] averaged over an eight-hour period) and a permissible exposure limit (50 ug/m^3 averaged over an eight hour period) for employees. Both standards require employers to conduct initial exposure monitoring and to provide employees written notification of these monitoring results. If employee exposure levels exceed the permissible exposure limit (PEL), employers are required to develop a written compliance program that addresses the implementation of feasible engineering and/or work practice controls to reduce and maintain employee exposures below the PEL. The Lead Exposure in Construction Standard (Part 603) also allows the use of administrative controls to achieve this objective. An employer's obligations concerning hygiene facilities, protective work clothing and equipment, respiratory protection, medical surveillance and training under the Lead Exposure in Construction Standard (Part 603) are triggered initially by job tasks and secondarily by actual employee exposure level to lead. Under the Lead Exposure in General Industry Standard (Part 310), these potential obligations are triggered by actual employee exposure levels to lead. Medical surveillance and training are triggered by exposures above the action level (AL), whereas protective clothing and equipment, respiratory protection and hygiene facilities are triggered by exposures above the PEL.

The medical surveillance program requirements for Michigan's Lead Exposure in General Industry Standard (Part 310) versus those required in Lead Exposure in Construction Standard (Part 603) do vary. Under the Lead Exposure in General Industry Standard (Part 310), a medical surveillance program must be implemented which includes periodic biological monitoring (blood tests for lead and zinc protoporphyrin [ZPP] levels), and medical exams/consultation for all workers exposed more than 30 days per year to lead levels exceeding the AL. Under the Lead Exposure in Construction Standard (Part 603), a distinction is made between "initial medical surveillance" (consisting of biological monitoring in the form of blood sampling and analysis for lead and ZPP levels) and secondary medical surveillance (consisting of follow-up biological monitoring and a medical examination/consultation). The initial medical exam is triggered by employee exposure to lead on any day at or above the AL. The secondary medical exam is triggered by employee exposures to lead at or above the AL for more than 30 days in any 12 consecutive months period.

Michigan's Lead Exposure in General Industry Standard (Part 310) mandates that employees exposed at or above the AL must be removed from the lead exposure when:

- A periodic blood test and follow-up blood test indicate that the blood lead level (BLL) is at or above 60 micrograms per deciliter (µg/dL) of whole blood.
- Medical removal is also triggered if the average of the last three BLL or the average of all blood sampling tests conducted over the previous six months, whichever is longer, indicates the employees blood lead level is at or above 50 µg/dL. Medical removal is not required however, if the last blood sampling test indicates a blood lead level at or below 40 µg/dL of whole blood.
- When a final medical determination reveals that an employee has a detected medical condition which places that employee at an increased risk of material impairment to health from the lead exposure.

The Lead Exposure in Construction Standard (Part 603) mandates removal of an employee from a lead exposure at or above the AL when:

- A periodic and follow-up blood test indicates that an employee's BLL is at or above 50 µg/dL; or
- There is a final medical determination that an employee has a detected medical condition which places that employee at an increased risk of material impairment to health from the lead exposure.

When an employee can return to work at their former job also differs by standard. The Lead Exposure in General Industry Standard (Part 310) allows an employee to return to his or her former job status under any of the following circumstances:

- If the employee's BLL was at or above 70 µg/dL, then two consecutive blood tests must have the BLL at or below 50 µg/dL.
- If the employee's BLL was at or above 60 µg/dL or due to an average BLL at or above 50 µg/dL, then two consecutive BLL must be at or below 40 µg/dL.
- For an employee removed due to a final medical determination, when a subsequent medical determination no longer detects a medical condition which places the employee at an increased risk of material impairment to health from exposure to lead.

The Lead Exposure in Construction Standard (Part 603) allows the employer to return an employee to their former job status under these circumstances:

- If the employee's BLL was at or above 50 µg/dL, then two consecutive blood tests must have the employee's BLL at or below 40 µg/dL.
- For an employee removed due to a final medical determination, when a subsequent medical determination no longer has a detected medical condition which places the employee at an increased risk of material impairment to health from exposure to lead.

Both the Lead Exposure in General Industry (Part 310) and Lead Exposure in Construction (Part 603) Standards have a medical removal protection benefits provision. This provision requires employers maintain full earnings, seniority and other employment rights and benefits of temporarily removed employees up to 18 months on each occasion that an employee is removed from exposure to lead. This includes the right to their former job status as though the employee had not been medically removed from the job or otherwise medically limited.

Provisions of Lead Exposure in General Industry (Part 310) and Lead Exposure in Construction (Part 603) Standards

Workers exposed to lead have a right to: an exposure assessment, respiratory protection, protective clothing and equipment, hygiene facilities, medical surveillance, medical removal and training. The triggering mechanisms that activate these rights are primarily based upon employee lead exposure levels. However, under the Lead Exposure in Construction Standard (Part 603), many of these rights are initially triggered by the specific work activity being performed.

Exposure Assessment

Air monitoring must be conducted to determine employee airborne lead exposure levels when a potential lead exposure exists. Under the Lead Exposure in Construction Standard (Part 603), however, specific work activities are identified/categorized that require "interim protection" (i.e., respiratory protection, personal protective clothing and equipment, work clothes change areas, hand washing facilities, biological monitoring and training) until air monitoring has been performed that establishes that these lead exposure levels are within the acceptable limits (AL or PEL).

Respiratory Protection

Respiratory protection is required whenever employee exposure levels exceed the PEL and as an interim control measure under the Lead Exposure in Construction Standard (Part 603). The level of respiratory protection required is dependent upon the actual employee exposure level or by the job activities identified in the Lead Exposure in Construction Standard (Part 603).

Protective Clothing/Equipment

Protective clothing/equipment (i.e., coveralls or similar full body clothing; gloves, hats, shoes or disposable shoe coverlets; and face shield, vented goggles, or other applicable equipment) is required whenever employee exposure levels exceed the PEL and as an interim protection measure under the Lead Exposure in Construction Standard (Part 603).

Hygiene Facilities

Hygiene facilities (i.e., clothing change areas, showers, eating facilities) are required whenever employee exposures to lead exceed the PEL. Except for shower facilities, these same hygiene facilities must be provided as interim protection under the Lead Exposure in Construction Standard (Part 603). The construction employer must, however, provide hand washing facilities in lieu of the shower facility as an interim protection.

Medical Surveillance

Medical surveillance (i.e., medical exam and consultation) is required when workers are exposed to lead at or exceeding the AL for more than 30 days a year. Biological blood sampling and analysis to determine lead and ZPP levels is required initially under the Lead Exposure in Construction Standard (Part 603) when employee lead exposure is at or exceeds the AL on any single day. Under the Lead Exposure in General Industry Standard (Part 310), it is required when employees are exposed to concentrations of airborne lead greater than the A.L. for more than 30 days per year.

Medical Removal

Workers covered by the Lead Exposure in General Industry (Part 310) Standard have the right to be removed from airborne lead exposures at or above the AL when their periodic and follow-up blood lead level is at or above 60 µg/dL or when an average of the last three BLLs or the average of all blood sampling tests conducted over the previous six months, whichever is longer, indicates the employee blood lead level is at or above 50 µg/dL. However, under this later removal criteria, they are not required to be removed if the last blood sampling test indicates a blood lead level at or below 40 µg/dL.

Workers covered by the Lead Exposure in Construction Standard (Part 603) have the right to be removed from airborne lead exposures at or above the AL on each occasion that a periodic and follow-up blood sample test indicate that the employee's blood lead level is at or above 50 µg/dL.

Under both the Lead Exposure in General Industry (Part 310) and Lead Exposure in Construction (Part 603) Standards, workers also have the right to be removed from airborne lead exposures at or above the AL whenever there is a final medical determination that has detected that they have a medical condition that places them at an increased risk of material impairment to health from exposure to lead.

Training

Under the Lead Exposure in General Industry Standard (Part 310) and Lead Exposure in Construction (Part 603), employees exposed to any level of airborne lead must be informed of the contents of appendices A and B from that standard.

Under both the Lead Exposure in General Industry (Part 310) and Lead Exposure in Construction (Part 603) Standards, employees who are exposed at or above the AL on any day or who are subject to exposure to lead compounds which may cause skin or eye irritation must be provided comprehensive training covering all topics specified in those standards.

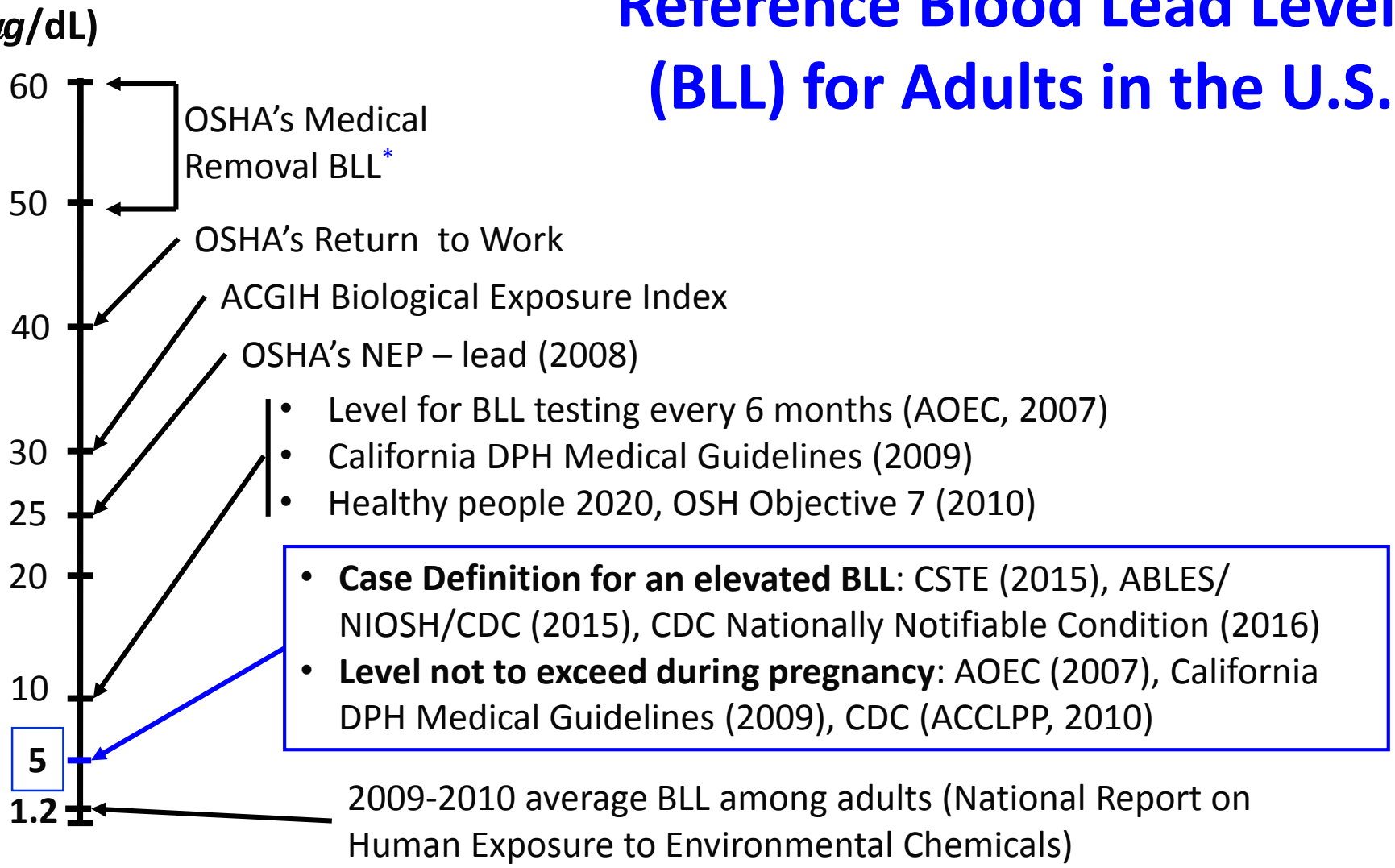
Also, under the Lead Exposure in Construction Standard (Part 603), employees involved in any of the specified work activities requiring interim controls, must receive training prior to initiating those activities that addresses the recognition and avoidance of unsafe conditions involving lead and the specific regulations applicable to the worksite that have been established to control or eliminate the hazards associated with exposure to lead.

APPENDIX C

Reference Blood Lead Levels (BLL) for Adults in the U.S.

Slide updated 12/18/2015

Reference Blood Lead Levels (BLL) for Adults in the U.S.



*The OSHA Lead Standards state that the examining physician has broad flexibility to tailor protections to the worker's needs.

Source Documents for Reference Blood Lead Levels in slide 1

1. **Occupational Safety and Health Administration (OSHA). Lead Standards:** http://www.osha.gov/SLTC/lead/
2. **American Conference of Governmental Industrial Hygienists (ACGIH). Biological Exposure Indices:** http://www.acgih.org/Products/beiintro.htm
3. **OSHA Instruction: National Emphasis Program (NEP) on Lead:** http://www.osha.gov/OshDoc/Directive_pdf/CPL_03-00-0009.pdf "Inspections will also be conducted in establishments where reported employee blood lead levels were at or above 25 µg/dL"
4. **Association of Occupational and Environmental Clinics (AOEC). Medical Management Guidelines for Lead-Exposed Adults, Revised 04/24/2007. CSTE Medical Management Guidelines Added October 2013, see Pages 16-17:** http://www.aoec.org/documents/positions/mmg_revision_with_cste_2013.pdf
5. **Kosnett MJ et al. Recommendations for Medical Management of Adult Lead Exposure.** http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1849937/
6. **California Department of Public Health (CDPH) Medical Guidelines for the Lead-Exposed Worker:** http://www.cdph.ca.gov/programs/olppp/Documents/medgdln.pdf
7. **Department of Health and Human Services. Healthy People 2020 Occupational Safety and Health objective 7 (OSH-7):** http://www.healthypeople.gov/2020/topics-objectives/topic/occupational-safety-and-health/objectives **and operational definition in** http://www.healthypeople.gov/node/5049/data_details
8. **Council of State and Territorial Epidemiologists (CSTE) Position Statement 15-EH-01. Public Health Reporting and National Notification for Elevated Blood Lead Levels.** http://c.ymcdn.com/sites/www.cste.org/resource/resmgr/2015PS/2015PSFinal/15-EH-01.pdf
9. **Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH), Adult Blood Lead Epidemiology and Surveillance (ABLES) case definition for an elevated blood lead level:** http://www.cdc.gov/niosh/topics/ABLES/description.html
10. **CDC. National Notifiable Diseases Surveillance System (NNDSS). Nationally Notifiable Non-Infectious Conditions. Lead, Elevated Blood Levels 2016 Case Definition:** http://wwwn.cdc.gov/nndss/conditions/lead-elevated-blood-levels/case-definition/2016/
11. **CDC. Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP): Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women**: http://www.cdc.gov/nceh/lead/publications/LeadandPregnancy2010.pdf These guidelines recommend follow-up activities and interventions beginning at blood lead levels (BLLs) ≥ 5 µg/dL in pregnant women. The essential activity in management of pregnant women with BLLs ≥5 µg/dL is removal of the lead source, disruption of the route of exposure, or avoidance of the lead-containing substance or activity.
12. **National Toxicology Program (NTP). Health Effects of Low-level Lead Evaluation**: http://ntp.niehs.nih.gov/go/36443
13. **CDC. National Report on Human Exposure to Environmental Chemicals.** http://www.cdc.gov/exposurereport/ **Updated tables, February 2015:** http://www.cdc.gov/biomonitoring/pdf/FourthReport_UpdatedTables_Feb2015.pdf

Appendix D

Management Guidelines for Blood Lead Levels in Adults

MANAGEMENT GUIDELINES FOR BLOOD LEAD LEVELS IN ADULTS

The following categories represent general guidelines. Blood lead level (BLL) monitoring should be done on a schedule based on an individual's risk of exposure to lead. **Primary management of lead poisoning is source identification and the elimination or reduction of further exposure.** A single BLL does not reflect cumulative body burden, nor predict long-term effects. Recent evidence suggests that chronic low-level lead exposure has adverse health effects in adults and no blood lead threshold level for these effects has been identified. Treatment decisions, including chelation, should be made in consultation with a physician knowledgeable about lead poisoning medical management. Centers for Disease Control and Prevention (CDC, 2012) report that the mean BLL for US adults age 20 years and older is 1.38 μg/dL.

Blood Lead Level (μg/dL)	Management Recommendations
<5	No action needed Monitor BLL if ongoing exposure
5-9	Discuss health risks Minimize exposure Consider removal for pregnancy and certain medical conditions Monitor BLL
10-19	Decrease exposure Remove from exposure for pregnancy Consider removal for certain medical conditions or BLL ≥ 10 for an extended period of time Monitor BLL
20-29	Remove from exposure for pregnancy Remove from exposure if repeat BLL in 4 weeks remains ≥ 20 Annual lead medical exam recommended
30-49	Remove from exposure Prompt medical evaluation
50-79	Remove from exposure Prompt medical evaluation Consider chelation with significant symptoms
≥ 80	Remove from exposure Urgent medical evaluation Chelation may be indicated

Note:The above management guidelines recommend removal from lead exposure at blood lead levels that are lower than those at which Medical Removal Protection is required under the current OSHA lead standards. However, OSHA job protections also apply whenever a licensed health care provider removes an individual from lead exposure, whatever the patient's blood lead level, if the individual has a lead related problem or has a medical condition that places the worker at greater risk from lead exposure. Because of the complexity in recommending medical removal below levels required by OSHA, a physician making such a recommendation may want to review the OSHA regulations, consult with a physician familiar with the regulatory process and discuss with their patient how this may affect their employment. For further information on this topic, please see the medical removal protection provisions of the OSHA lead standards.

Medical Guidelines:

"Medical Guidelines for the Lead-Exposed Worker"

http://www.cdc.gov/niosh/topics/ABLES/publication.html – scroll down to "State Publications" and click on the link for *Medical Guidelines for the Lead-Exposed Worker*.

"Association of Occupational and Environmental Clinics Medical Management Guidelines for Lead-Exposed Adults"

http://www.aoec.org/documents/positions/MMG_FINAL.pdf

"Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women"

http://www.cdc.gov/nceh/lead/publications/leadandpregnancy2010.pdf

For Additional Information

See below for additional information on related topics such as OSHA offices, occupational and environmental medicine clinics, childhood lead poisoning, environmental exposure assessments or take-home lead poisoning identification/prevention (Note that lead dust from a job can be taken home and expose other household members to lead when work clothes and shoes are worn home):

- Contact your local and/or state health department
- http://www.cdc.gov/nceh/lead/publications/#screening - click on Screening and Case Management Guidelines
- http://www.osha.gov/html/RAmap.html - use this map to find an OSHA Office in your State
- http://www.aoec.org/directory.htm - Online directory of member clinics of the Association of Occupational and Environmental Clinics