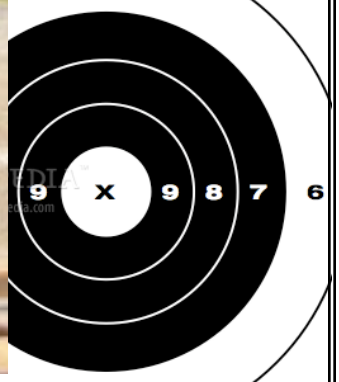
2012 - 2013
Annual Report on Blood Lead Levels on Adults in Michigan

January 25, 2016



2012-2013 ANNUAL REPORT

Adult Blood Lead Epidemiology Surveillance (ABLES) Program

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Executive Summary

This is the fifteenth report on surveillance of blood lead levels (BLLs) in Michigan and covers residents 16 years and older whose blood lead was tested in Michigan in 2012 and 2013.

- In 2012, Michigan received 15,329 blood lead tests for 13,605 individuals who were ≥16 years of age. Six hundred and thirty-three (4.7%) individuals had BLLs ≥ 10 µg/dL; 131 of those 633 had lead levels ≥ 25 µg/dL and 9 of the 131 had BLLs ≥ 50 µg/dL.
- In 2013, Michigan received 14,071 blood lead tests for 12,716 individuals who were ≥16 years of age. Five hundred and ninety-six (4.7%) individuals had BLLs ≥ 10 µg/dL; 108 of those 596 had lead levels ≥ 25 µg/dL and 11 of the 108 had BLLs ≥ 50 µg/dL.
- There were 689 fewer blood lead tests and 245 fewer individuals reported in 2012 compared to

Executive Summary, continued

2011 and 1,258 fewer blood lead tests and 889 fewer individuals reported in 2013 compared to 2012.

- The number and the percent of individuals with BLLs ≥10 µg/dL increased from 625 (4.5%) in 2011 to 633 (4.7%) in 2012 but the number decreased to 596 while the percentage (4.7%) was unchanged in 2013.
- The number and percent of individuals with BLLs ≥25 µg/dL increased from 116 (0.8%) in 2011 to 131 (0.96%) in 2012 but then decreased to 108 (0.8%) in 2013. The number of individuals with BLLs ≥ 50 µg/dL went from thirteen (0.09%) in 2011 to nine (0.07%) in 2012 but then increased to eleven (0.09%) in 2013.
- When individuals tested in both 2012 and 2013 are only counted once, there were 24,178 individuals of whom 990 (4.1%) individuals had BLLs ≥10 µg/dL, 198 (0.8%) had BLLs ≥25 µg/dL, and 18 (0.07%) had BLLs ≥ 50 µg/dL.
- 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 but in 2013 dropped to 108. These trends occurred among both work and non-work exposures. The overall trend for work and non-work exposures was similar showing a downward trend until 2005 with no further decrease in BLLs ≥10 µg/dL from 2006 through 2012. In 2013, there was a decrease in elevated BLLs from work but not non-work exposures.
- Among adults with BLLs ≥10 µg/dL, work-related exposure was the predominant source of lead exposure (82%); including work in abrasive blasting to remove lead paint on outdoor metal structures such as bridges, overpasses or water towers; casting of brass or bronze fixtures; 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, 69% of lead exposure was from firing ranges, reloading and casting of bullets.
- Outreach and intervention activities included written contact with 241 individuals, follow-up interviews with 117 lead-exposed individuals, and distribution of resources on diagnosis and management of lead exposure to 81 health care providers who tested patients with elevated blood lead levels. A “how to” guide for home maintenance and renovation from the U.S. Department of Housing and Urban Development was provided to individuals whose source of exposure to lead was renovation. Three educational brochures were distributed: one on working safely with lead, the second on controlling lead exposure in firing ranges and a third brochure for reducing lead exposure when reloading firearms or casting lead as a hobby (www.oem.msu.edu under Resources for Adult Blood Lead (ABLES)). 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.
- Children of adults with elevated blood lead who are under the age of six are a high risk group with 33.4% having an elevated blood lead level of at least 10 µg/dL from exposure to lead brought home on the work clothes or shoes of the adult exposed at work.
- Seven of ten (70.0%) Michigan Occupational Safety and Health Administration (MIOSHA) inspections for elevated blood lead laboratory reports in 2012-2013 had lead-related citations.

Background

This is the fifteenth report on surveillance of BLLs in Michigan. It provides detailed data on residents 16 years and older whose blood lead was tested in Michigan in 2012 and 2013, with a focus on individuals with work-related exposure. It also 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 Michigan state 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 children and adults to the MDHHS for any blood testing for lead. Coincident with the promulgation of this regulation in 1997, Michigan received federal funding from the Centers for Disease Control and Prevention (CDC), to monitor adult BLLs as part of the Adult Blood Lead Epidemiology Surveillance (ABLES) program. Up to 41 states have established lead registries through the ABLES program for surveillance of adult lead absorption, primarily based on reports of elevated BLLs from clinical laboratories. The most recent report of U.S. adult blood lead surveillance, published in the *Morbidity and Mortality Weekly Report*, October 23, 2015, 62(54):52-75, is in Appendix A.

The surveillance for lead exposure in adults has focused on occupational exposure, because 70% 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 and medical removal. See Appendix B for a summary of the two standards.

The MIOSHA requirements for medical surveillance (i.e. biological monitoring) 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 taken pursuant to the standard above 50 µg/dL. However, an employee is not required to be removed if the last blood-sampling test indicates a blood lead level ≤ 40 µg/dL. If monitoring shows lead levels above 30 µg/m^3 of air (MIOSHA's action limit) but below environmental 50 µg/m^3 of air (PEL), an employer also must repeat air monitoring every six months, repeat training annually, provide medical surveillance, including blood sampling 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 (1). Also of note, in 2012 CDC recommended that BLLs five µg/dL or greater in children should be considered elevated, but did not review this issue for adults (2). CDC had previously considered blood leads of ten µg/dL or greater as a level of concern. Both the Association for Occupational and Environmental Clinics (AOEC) (http://www.aoec.org/documents/positions/mmg_revision_with_cste_2013.pdf) and the Council for State and Territorial Epidemiologists (CSTE) (http://c.ymcdn.com/sites/www.cste.org/resource/resmgr/OccupationalHealth/ManagementGuidelinesforAdult.pdf) have adopted medical

Background, continued

guidelines that recommend a medical response for levels of five µg/dL or greater in adults and in 2014 CSTE recommended that a BLL of five µg/dL or greater be considered elevated for adults as well as children (http://c.ymcdn.com/sites/www.cste.org/resource/resmgr/2015PS/2015PSFinal/15-EH-01.pdf) and that surveillance for adults reflect this definition change.

THE MICHIGAN ADULT BLOOD LEAD REGISTRY

Methods

Reporting Regulations and Mechanism

Since October 11, 1997, laboratories performing blood lead analyses are 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 lead levels among adults were received.

The laboratories are required to report blood sample analysis results, patient demographics, and employer information electronically. The health care 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.

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 be in compliance with the lead standard. Figure 1 details the six OSHA-approved laboratories in Michigan.

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.

Figure 1 Michigan Laboratories Meeting OSHA Proficiency Testing for Blood Lead Analysis

MICHIGAN BLOOD LEAD LABORATORIES*

Laboratory Name	*City*
DMC University Laboratories	Detroit
McLaren Medical Laboratory	Flint
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 August 3, 2015. For a complete listing of OSHA-approved blood lead laboratories, visit the OSHA web site at http://www.osha.gov/SLTC/bloodlead/program.html**

Data Management

The MDHHS CLPPP forwards the electronic file of all blood lead results on individuals 16 years or older 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.

When BLL reports are received they are reviewed for completeness. For blood lead reports ≥ 10 µg/dL, requests are sent to the provider who ordered the test to provide any missing information. No follow up is performed on blood leads less than 10 µg/dL. Each record entered into the database is visually checked for any data entry errors, duplicate entries, missing data, and illogical data. These quality control checks are performed monthly.

Case Follow-Up

An adult who has a BLL of 25 µg/dL or greater is contacted for an interview. Interviews are 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. A letter is sent to 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 elevated blood lead levels whose employers are identified, MSU notifies the Michigan Occupational Safety and Health Administration (MIOSHA) in the Michigan Department of Licensing and Regulatory Affairs (LARA) for a potential work-place follow-up.

Dissemination of Surveillance Data

In addition to Michigan's annual ABLES surveillance summaries, Michigan's ABLES data are forwarded to the program's funding agency, the National Institute for Occupational Safety and Health (NIOSH) at CDC, without identifiers once a year. NIOSH compiles surveillance summaries compiling data from all states that require reporting of BLLs and publishes them in the Morbidity and Mortality Weekly Report (MMWR). See Appendix A for the most recent publication of ABLES surveillance results for the period 1994 -2012.

This annual report provides a summary of data from reports of all adult BLLs received in 2012 and 2013 along with annual trends in numbers of adults reported with elevated BLLs going back to 1998. Also included is information about the Michigan Occupational Safety and Health Administration (MIOSHA) inspections completed in 2012 and 2013 at the work sites where reported individuals were exposed to lead.

Information is provided on households where adults with elevated BLLs had children age 6 and younger living or spending time in the home. There is increasing 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 over 80% of BLLs ranging from 5-9 µg/dL (Table 1).

Results

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

Table 1 Distribution of Highest Blood Lead Levels among Adults and Source of Exposure in Michigan: 2012 – 2013 combined

	Work BLLs		Non-Work BLLs		Source Not Yet Identified		All BLLs	
BLLs (ug/dL)	Number	Percent	Number	Percent	Number	Percent	Number	Percent
<5	289	[a]	13	[a]	21,452	[a]	21,754	90.0
5-9	227	[a]	33	[a]	1,174	[a]	1,434	5.9
10-24	580	47.3	105	52.0	107	0.5	792	3.3
25-29	64	5.2	22	10.9	9	0.0	95	0.4
30-39	47	3.8	20	9.9	6	0.0	73	0.3
40-49	9	0.7	3	1.5	0	0.0	12	0.0
50-59	7	0.6	2	1.0	0	0.0	9	0.0
≥ 60	4	0.3	4	2.0	1	0.0	9	0.0
TOTAL	**1,227**	**84.9[e]**	**202**	**15.1[e]**	**22,749**		**24,178** [b]	**100.0**
TOTAL≥10ug/dL	**711***	**81.2[c]**	**156**	**18.8[c]**	**123**	**0.5**	**990**	**4.1**
TOTAL≥25ug/dL	**131**	**73.9[d]**	**51**	**26.1[d]**	**16**	**0.07**	**198**	**0.8**

*Work category includes 13 adults with BLLS ≥10 ug/dL whose exposure to lead was from both work and non-work activities.

[a] No follow-up is conducted of individuals with blood leads < 10 ug/dL, but often information is known.
[b] In 2012-13, 29,400 BLL reports were received for 24,178 individuals. [d] percent of known exposures >25 µg/dL
[c] percent of known exposures >10 µg/dL [e] percent of total known exposures

Results, continued

Number of Reports and Individuals

2012-2013: Between January 1, 2012 and December 31, 2013, the State of Michigan received 29,400 blood lead test reports for individuals 16 years of age or older. Because an individual may be tested more than once each year, and/or during two consecutive years, the 29,400 reports received were for 24,178 individuals. Between January 1 and December 31, 2012, the State of Michigan received 15,329 BLLs on 13,605 individuals, and between January 1 and December 31, 2013, 14,071 reports for 12,716 individuals (Figure 2). Two thousand one hundred and forty-three individuals had BLLs in both 2012 and 2013.

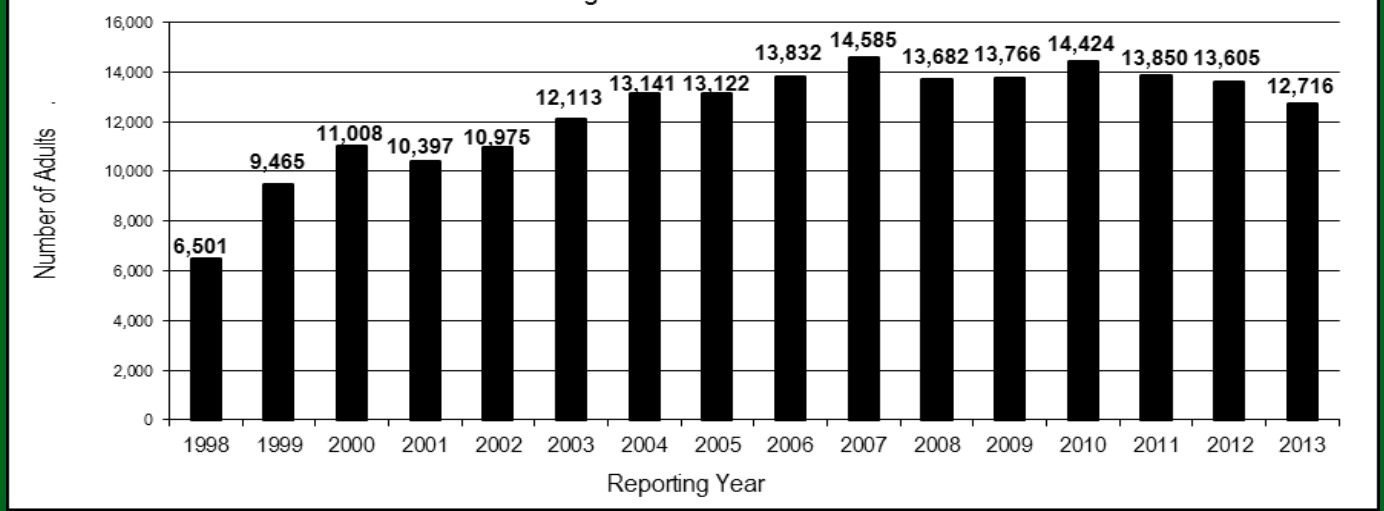
1998-2013 Trends: Up to 2007, the overall trend for the number of individuals tested each year has shown a gradual increase (Figure 2). The initial increase in 1999 and 2000 was most likely secondary to better compliance by the laboratories with the 1997 reporting regulation. The increase after 2000 is assumed secondary to increased testing while the drop in numbers of tests noted in 2008 and 2009 was likely a reflection of the economic downturn. The reason for the more recent decline in the number of individuals tested is not known.

Distribution of BLLs and Exposure Sources

Note: For individuals with multiple BL tests, the highest BLL is selected.

2012-2013 Combined: In 2012 and 2013, 990 (4.1%) of the 24,178 adults reported had BLLs ≥ 10 µg/dL; 198 of those 990 had BLLs ≥ 25 µg/dL and 18 of 198 had BLLs≥ 50 µg/dL (Table 1).

A total of 21,754 (90.0%) of adults reported in 2012 and 2013 had a BLL less than 5 µg/dL, and 1,434



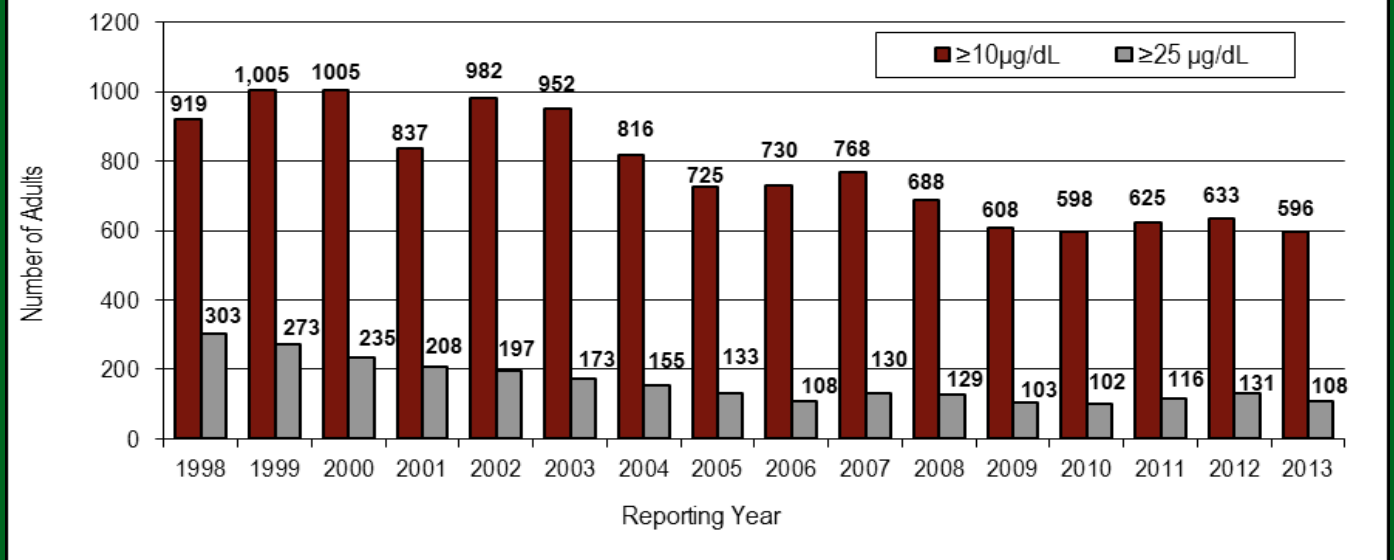
Results, continued

(5.9%) were from individuals whose blood lead was 5 – 9 µg/dL. Individuals with a BLL of 5 – 9 µg/dL are not routinely contacted; however when the source of lead exposure was identified, 226 of 260 (86.9%) individuals were identified as occupationally exposed. One hundred and ninety (84.1%) of these 226 had been tested in previous years and 133 (70.0%) showed a decrease in their BLL. Among the 792 individuals whose blood lead was 10 – 24 µg/dL, 580 (73.2%) individuals had their source of lead exposure identified as occupational as compared to the 198 individuals with BLLs ≥ 25 µg/dL where 131 (66.2%) individuals had their source of lead exposure identified as occupational.

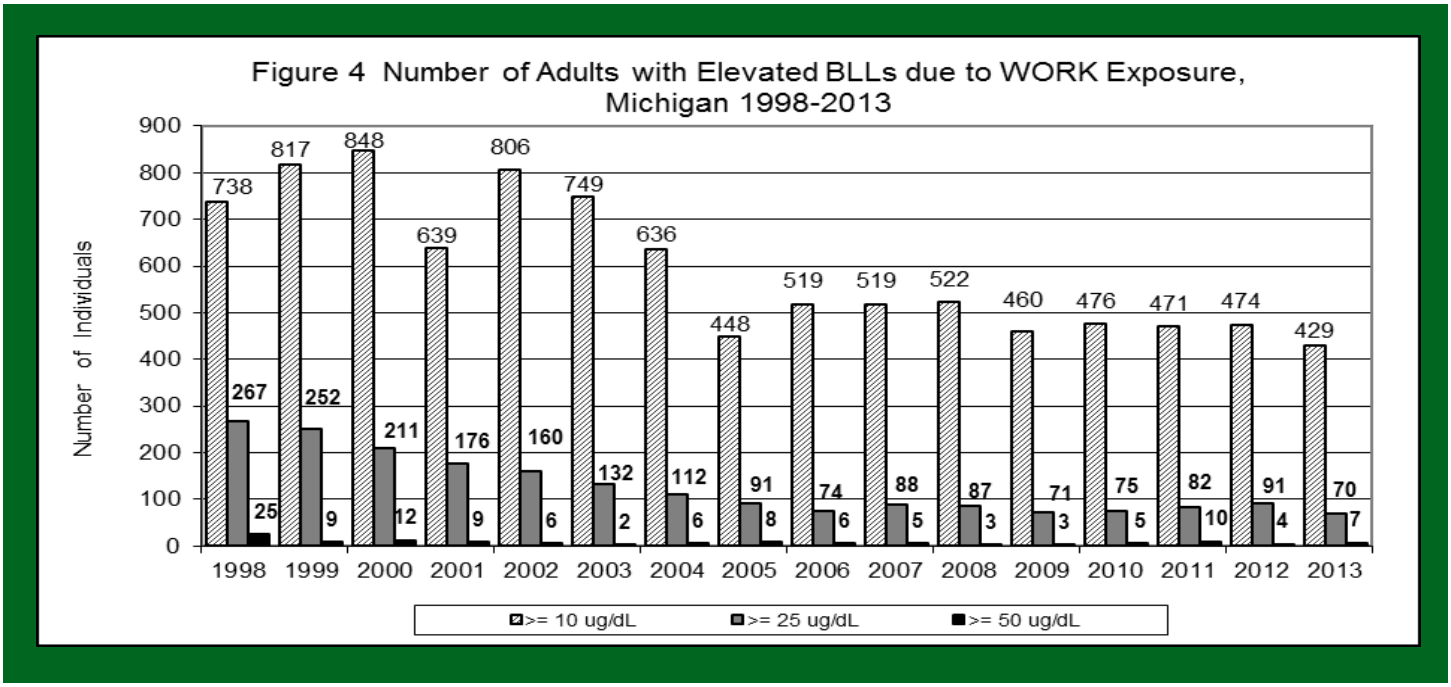
1998-2013 trends: For twelve consecutive years, from 1999 to 2010, there was a downward trend for BLLs ≥10 µg/dL and BLLs ≥25 µg/dL from each prior year (Figure 3). However, in 2011 and 2012, the number of BLLs ≥25 µg/dL increased from 102 in 2010 to 116 in 2011 and to 131 in 2012. In 2013, the number of BLLs ≥25 µg/dL dropped to 108.

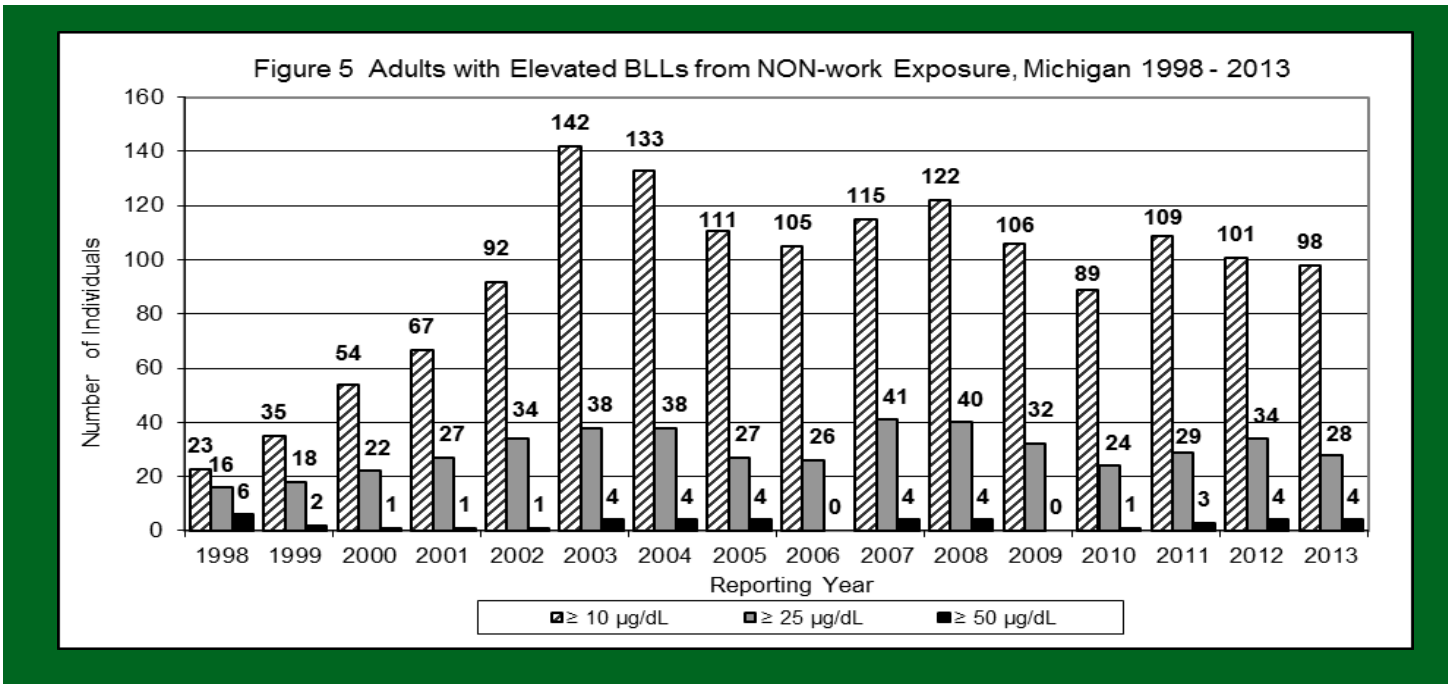
There was a marked decline in the overall number of individuals with elevated blood lead from occupational exposure from 2000 to 2005, with the number remaining fairly stable from 2006 to 2012 but then declining in 2013 (Figure 4). For non-work exposures, elevated blood lead showed a decline from 2003 to 2006, a slight increase in 2007 and 2008 and then a slight decrease from 2009 to 2013 (Figure 5).

Figure 3 Number of Adult BLLs ≥10 µg/dL and ≥25 µg/dL, Michigan 1998-2013



Results, continued





Gender and Age: 2012 - 2013

All Blood Lead Levels

Fifty-eight percent of the adults reported to the Registry were male, and forty-two percent were females (Table 2). The mean age was 44.8 and median age 43.9. The age distribution is shown in Table 3.

Results, continued

Table 2 Distribution of Gender Among Adults Tested for BLLs in Michigan: 2012-2013

	All Blood Lead Level Tests		All Blood Lead Levels ≥10 µg/dL		All Blood Lead Levels ≥25 µg/dL	
Gender	Number	Percent	Number	Percent	Number	Percent
Male	14,031	58.1	925	93.4	187	94.4
Female	10,134	41.9	65	6.6	11	5.6
Total	24,165*	100.0	990	100.0	198	100.0

*Gender was unknown for 13 additional individuals.

Table 3 Distribution of Age Among Individuals Tested for Blood Lead in Michigan: 2012-2013

	All Blood Lead Level Tests		Blood Lead Levels ≥ 10 ug/dL	
Age Range	Number	Percent	Number	Percent
16-19	1,846	7.6	10	1.0
20-29	4,103	17.0	148	14.8
30-39	4,197	17.4	201	20.1
40-49	4,371	18.1	234	23.4
50-59	4,384	18.1	240	24.0
60-69	2,791	11.5	111	11.1
70-79	1,599	6.6	39	3.9
80-89	764	3.2	7	0.7
90-99	89	0.4	0	–
100+	29	0.1	0	–
Total	24,173*	100.0	988**	100.0

*Age was unknown for 5 additional individuals; Age was unknown for 2 additional individuals.

BLLs ≥ 10 µg/dL

For the 990 adults reported to the Registry with BLLs ≥ 10 µg/dL, 925 (93.4%) were men and 65 (6.6%) were women. The mean age was 45.2 and median age was 44.9.

Race Distribution

All Blood Lead Levels

Although laboratories are required to report the patients' race, this information is frequently not pro-

Results, continued

vided. Race was missing for 16,490 (68.2%) of the 24,178 adults reported in 2012 and 2013. Where race was known, 6,489 (84.4%) were reported as Caucasian, 968 (12.6%) were reported as African American, 107 (1.4%) were reported as Asian/Pacific Islander, 87 (1.1%) were reported as Native American, and 37 (0.5%) were reported as Multi-racial/Other (Table 4).

BLLs ≥ 10 µg/dL

For adults with BLLs greater than or equal to 10 µg/dL where race was indicated, 492 (85.6%) were reported as Caucasian, 52 (9.0%) were reported as African American, 13 (2.3%) were reported as Asian/Pacific Islander, 9 (1.6%) each were reported as Native American and Multi-racial/Other (Table 4).

Table 4 Distribution of Race Among Adults Tested for Blood Lead in Michigan: 2012-2013

	All Blood Lead Level Tests		Blood Lead Levels ≥ 10 ug/dL	
Race	Number	Percent	Number	Percent
Caucasian	6,489	84.4	492	85.6
African American	968	12.6	52	9.0
Asian/Pacific Islander	107	1.4	13	2.3
Native American	87	1.1	9	1.6
Multi-racial/Other	37	0.5	9	1.6
Total	7,688*	100.0	575**	100.0

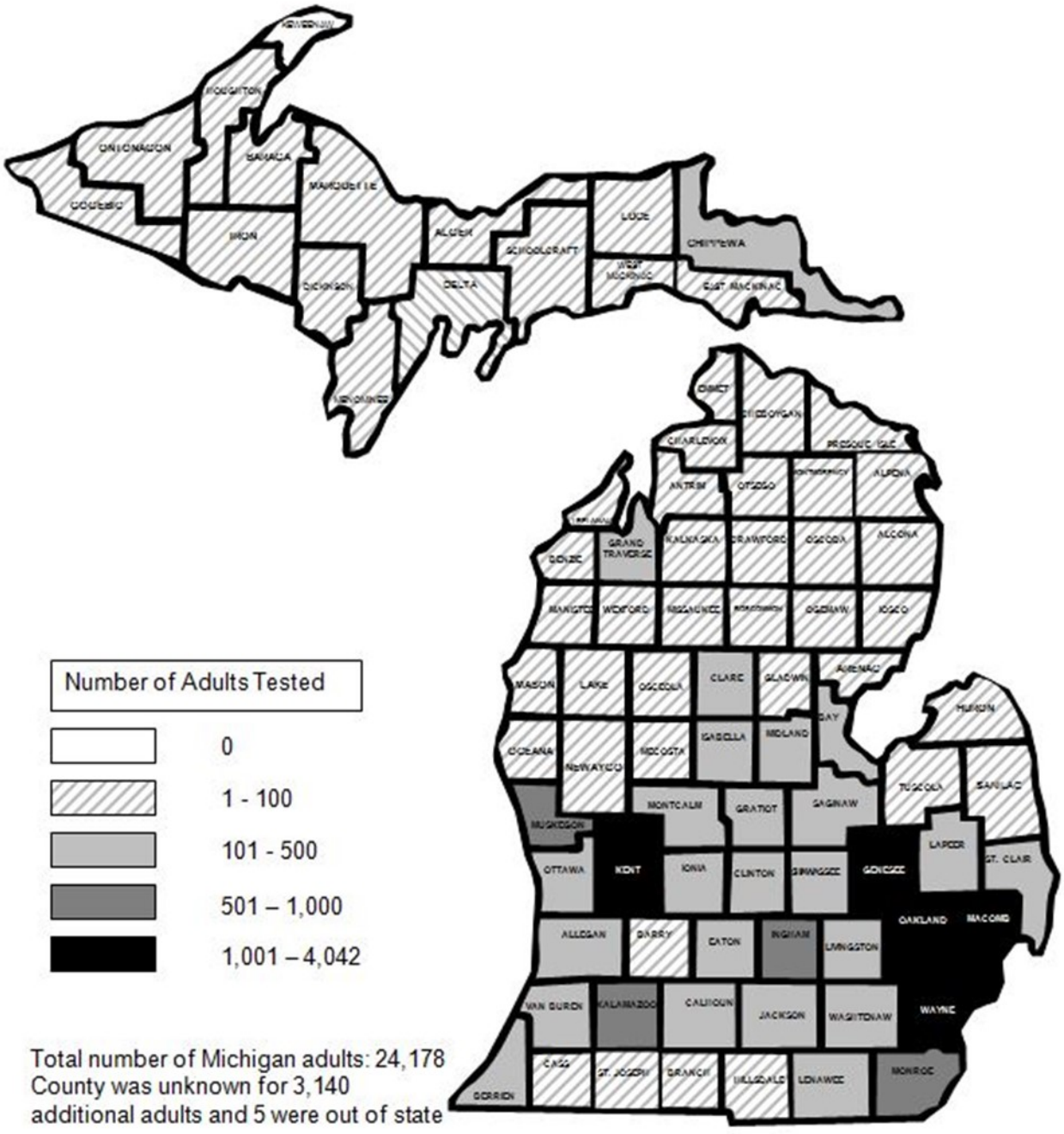
*Age was unknown for 16,490 additional individuals; **Age was unknown for 415 additional individuals.

Geographic Distribution

County of residence was determined for 21,033 of the 24,178 adults reported to the Registry. They lived in all of Michigan's 83 counties. The largest number of adults tested in 2012 and 2013 lived in Wayne County (4,042, 19.2%), followed by Kent County (2,246, 10.7%) and Oakland County (1,830, 8.7%). The county was unknown for 3,140 adults tested for blood lead (Figure 6 and Table 5).

Results, continued

Figure 6 **Geographic Distribution of Adults Tested for Lead In Michigan by County of Residence, 2012 - 2013**



Wayne and Kent counties had the highest number of adults tested with 4,042 and 2,246 respectively.

Results, continued

TABLE 5. Distribution of BLLs Among Adults in Michigan, by BLL Levels and County of Residence: 2012 - 2013

	All BLLs		BLLs >10 ug/dL			BLLs >25 ug/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	22	0.1	2	0.2	9.1	0	0.0	0.0
Alger	7	0.0	1	0.1	14.3	0	0.0	0.0
Allegan	192	0.9	7	0.9	3.6	1	0.6	0.5
Alpena	72	0.3	3	0.4	4.2	0	0.0	0.0
Antrim	48	0.2	0	0.0	0.0	0	0.0	0.0
Arenac	19	0.1	0	0.0	0.0	0	0.0	0.0
Baraga	4	0.0	0	0.0	0.0	0	0.0	0.0
Barry	91	0.4	2	0.2	2.2	0	0.0	0.0
Bay	315	1.5	8	1.0	2.5	0	0.0	0.0
Benzie	18	0.1	1	0.1	5.6	1	0.6	5.6
Berrien	125	0.6	8	1.0	6.4	0	0.0	0.0
Branch	27	0.1	2	0.2	7.4	0	0.0	0.0
Calhoun	268	1.3	9	1.1	3.4	3	1.9	1.1
Cass	39	0.2	0	0.0	0.0	0	0.0	0.0
Charlevoix	53	0.3	0	0.0	0.0	0	0.0	0.0
Cheboygan	55	0.3	6	0.7	10.9	3	1.9	5.5
Chippewa	110	0.5	5	0.6	4.5	2	1.3	1.8
Clare	117	0.6	2	0.2	1.7	1	0.6	0.9
Clinton	174	0.8	6	0.7	3.4	0	0.0	0.0
Crawford	69	0.3	1	0.1	1.4	0	0.0	0.0
Delta	41	0.2	2	0.2	4.9	0	0.0	0.0
Dickinson	24	0.1	2	0.2	8.3	0	0.0	0.0
Eaton	303	1.4	8	1.0	2.6	2	1.3	0.7
Emmet	50	0.2	1	0.1	2.0	0	0.0	0.0
Genesee	1,111	5.3	34	4.2	3.1	8	5.1	0.7
Gladwin	85	0.4	2	0.2	2.4	0	0.0	0.0
Gogebic	9	0.0	0	0.0	0.0	0	0.0	0.0
Grand Traverse	129	0.6	8	1.0	6.2	0	0.0	0.0
Gratiot	243	1.2	2	0.2	0.8	0	0.0	0.0
Hillsdale	75	0.4	1	0.1	1.3	0	0.0	0.0
Houghton	30	0.1	1	0.1	3.3	0	0.0	0.0
Huron	35	0.2	3	0.4	8.6	0	0.0	0.0
Ingham	671	3.2	18	2.2	2.7	6	3.8	0.9
Ionia	129	0.6	12	1.5	9.3	3	1.9	2.3
Iosco	26	0.1	0	0.0	0.0	0	0.0	0.0
Iron	7	0.0	0	0.0	0.0	0	0.0	0.0
Isabella	332	1.6	2	0.2	0.6	1	0.6	0.3
Jackson	192	0.9	12	1.5	6.3	5	3.2	2.6
Kalamazoo	511	2.4	15	1.8	2.9	5	3.2	1.0
Kalkaska	69	0.3	0	0.0	0.0	0	0.0	0.0
Kent	2,246	10.7	56	6.9	2.5	5	3.2	0.2
Keweenaw	0	0.0	0	0.0	0.0	0	0.0	0.0
Lake	15	0.1	0	0.0	0.0	0	0.0	0.0
Lapeer	167	0.8	6	0.7	3.6	1	0.6	0.6

Results, continued

TABLE 5. Distribution of BLLs Among Adults in Michigan, by BLL Levels and County of Residence: 2012 - 2013

	All BLLs		BLLs >10 ug/dL			BLLs >25 ug/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	27	0.1	2	0.2	7.4	0	0.0	0.0
Lenawee	193	0.9	9	1.1	4.7	2	1.3	1.0
Livingston	362	1.7	16	2.0	4.4	3	1.9	0.8
Luce	6	0.0	0	0.0	0.0	0	0.0	0.0
Mackinac	44	0.2	11	1.4	25.0	3	1.9	6.8
Macomb	1,401	6.7	77	9.5	5.5	26	16.6	1.9
Manistee	45	0.2	0	0.0	0.0	0	0.0	0.0
Marquette	55	0.3	2	0.2	3.6	0	0.0	0.0
Mason	27	0.1	1	0.1	3.7	0	0.0	0.0
Mecosta	76	0.4	2	0.2	2.6	0	0.0	0.0
Menominee	21	0.1	0	0.0	0.0	0	0.0	0.0
Midland	252	1.2	8	1.0	3.2	1	0.6	0.4
Missaukee	19	0.1	0	0.0	0.0	0	0.0	0.0
Monroe	564	2.7	30	3.7	5.3	5	3.2	0.9
Montcalm	236	1.1	24	2.9	10.2	3	1.9	1.3
Montmorency	22	0.1	1	0.1	4.5	0	0.0	0.0
Muskegon	921	4.4	19	2.3	2.1	1	0.6	0.1
Newaygo	75	0.4	2	0.2	2.7	0	0.0	0.0
Oakland	1,830	8.7	85	10.4	4.6	18	11.5	1.0
Oceana	64	0.3	0	0.0	0.0	0	0.0	0.0
Ogemaw	23	0.1	2	0.2	8.7	0	0.0	0.0
Ontonagon	9	0.0	1	0.1	11.1	0	0.0	0.0
Osceola	32	0.2	0	0.0	0.0	0	0.0	0.0
Oscoda	21	0.1	1	0.1	4.8	0	0.0	0.0
Otsego	48	0.2	2	0.2	4.2	1	0.6	2.1
Ottawa	301	1.4	10	1.2	3.3	1	0.6	0.3
Presque Isle	29	0.1	0	0.0	0.0	0	0.0	0.0
Roscommon	75	0.4	3	0.4	4.0	1	0.6	1.3
Saginaw	401	1.9	13	1.6	3.2	1	0.6	0.2
Saint Clair	456	2.2	58	7.1	12.7	4	2.5	0.9
Saint Joseph	50	0.2	5	0.6	10.0	0	0.0	0.0
Sanilac	77	0.4	6	0.7	7.8	0	0.0	0.0
Schoolcraft	6	0.0	0	0.0	0.0	0	0.0	0.0
Shiawassee	196	0.9	9	1.1	4.6	1	0.6	0.5
Tuscola	79	0.4	4	0.5	5.1	0	0.0	0.0
Van Buren	150	0.7	5	0.6	3.3	1	0.6	0.7
Washtenaw	439	2.1	15	1.8	3.4	2	1.3	0.5
Wayne	4,042	19.2	143	17.6	3.5	36	22.9	0.9
Wexford	34	0.2	0	0.0	0.0	0	0.0	0.0
TOTAL	**21,033***	100.0	**814****	100.0	3.9	**157*****	100.0	0.7

*County was unknown for 3,140 additional adults and 5 lived out of state
**County was unknown for 172 additional adults and 4 lived out of state
***County was unknown for 39 adults and 2 lived out of state

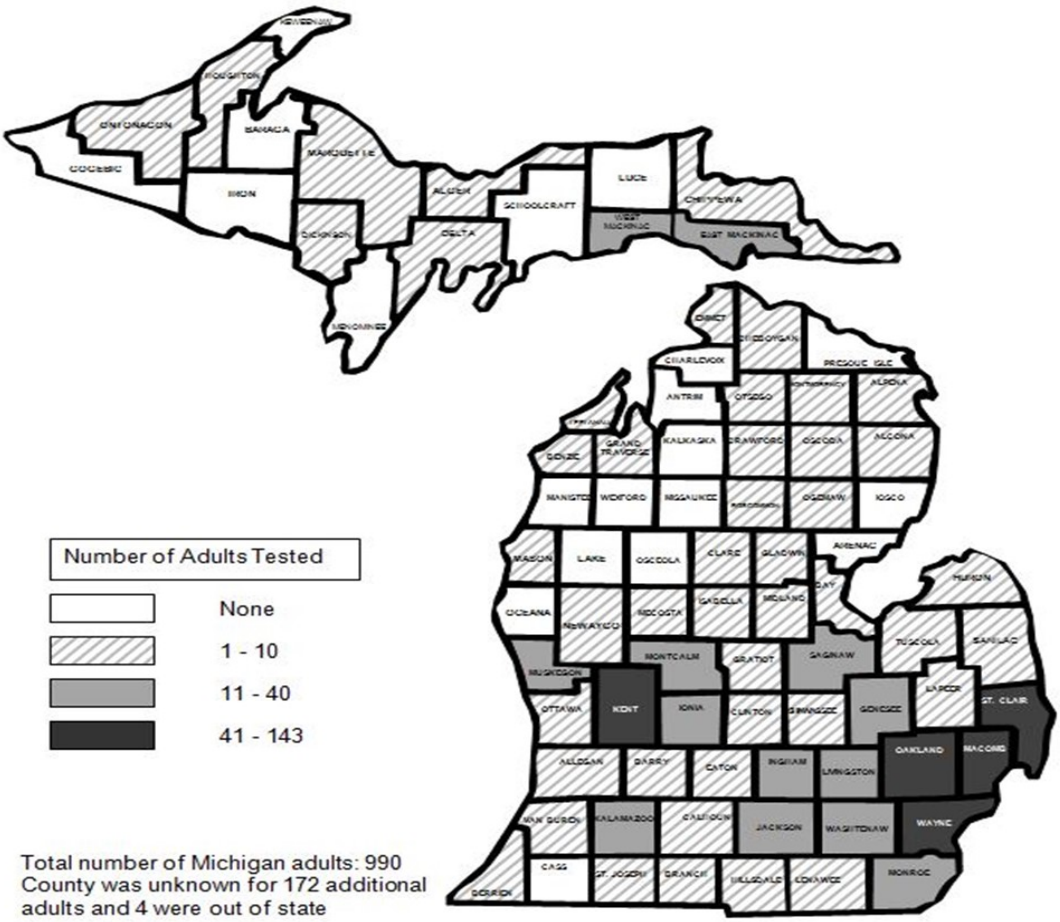
Results, continued

Figure 7 and Table 5 show the county of residence of the 814 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 (143, 17.6%), followed by Oakland County (85, 10.4%) and Macomb County (77, 9.5%). The county was unknown for 172 adults with BLLs ≥ 10 µg/dL.

Figure 8 and Table 5 show the county of residence for the 157 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 (36, 22.9%), followed by Macomb County (26, 16.6%) and Oakland (18, 11.5%). The county was unknown for 39 adults with BLLs ≥ 25 µg/dL.

Table 5 shows the percentage of tested adults, within each county, with BLLs ≥10 µg/dL and BLLs ≥ 25 µg/dL. Mackinac (25.0%), Alger (14.3%), Saint Clair (12.7%) and Ontonagon (11.1%) counties had the highest percentages of adults with BLL ≥10 µg/dL within their respective counties. Mackinac (6.8%), Benzie (5.6%), Cheboygan (5.5%) and Jackson (2.6%) counties had the highest percentage of tested adults with BLL ≥ 25 µg/dL.

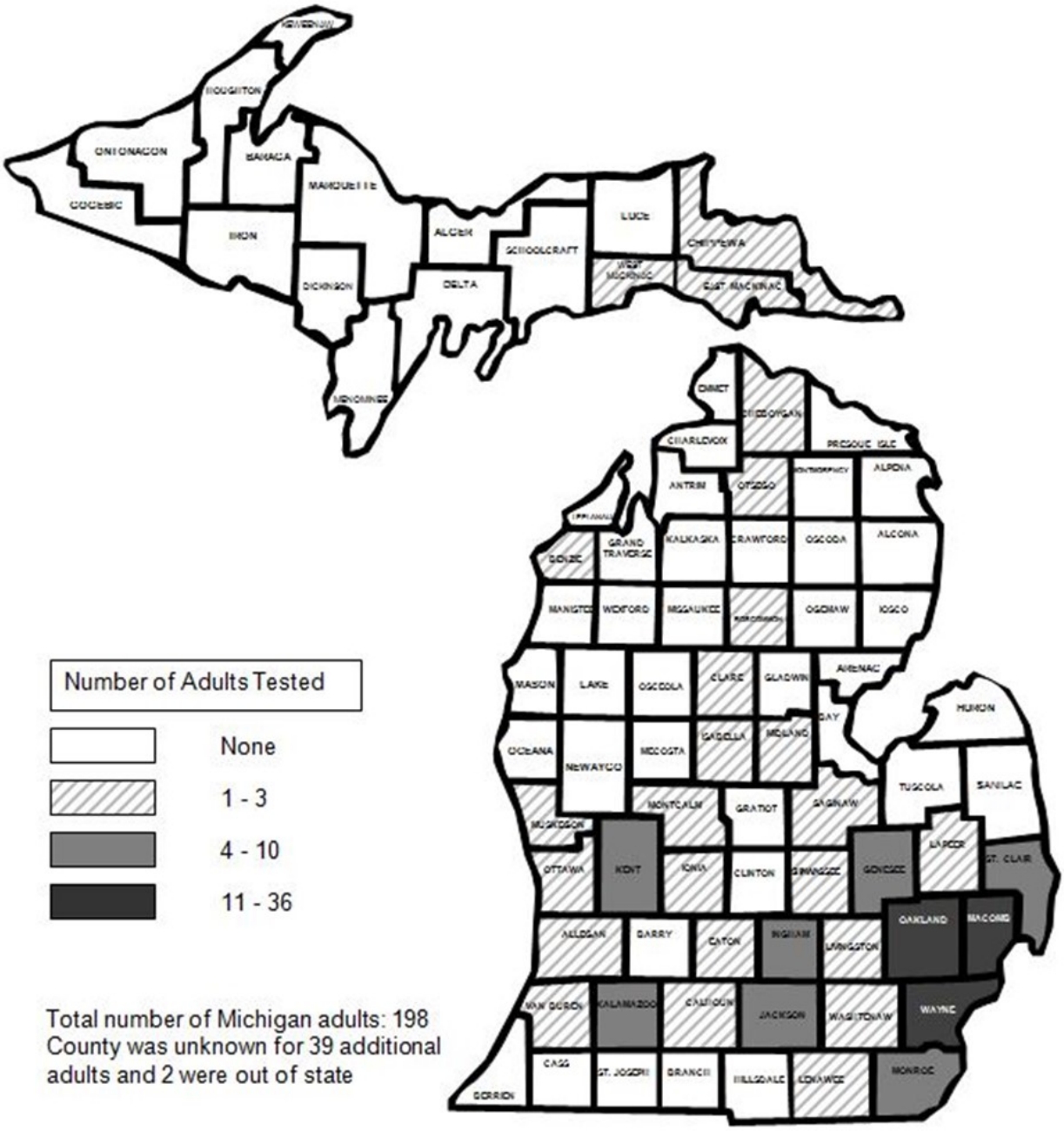
Figure 7 **Geographic Distribution of Adults Tested with BLLs ≥ 10 µg/dL In Michigan by County of Residence, 2012 - 2013**



Wayne, Oakland and Macomb counties had the largest numbers with 143, 85 and 77 respectively.

Results, continued

Figure 8 **Geographic Distribution of Adults Tested with BLLs ≥ 25 µg/dL In Michigan by County of Residence, 2012 - 2013**



Wayne, Macomb and Oakland counties had the largest numbers with 36, 26 and 18 respectively.

Results, continued

Gender Distribution

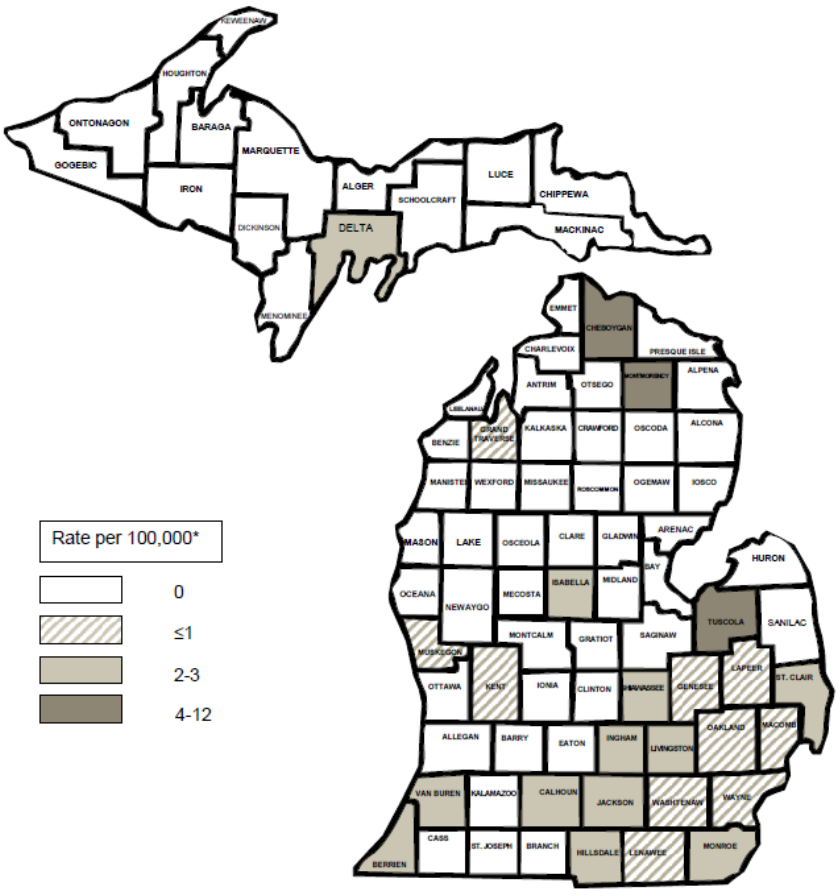
Figure 9 and Table 6 show the incidence rates of BLLs ≥ 10 µg/dL by county for women. There were 61 women reported in 2012 and 2013 with a BLL ≥ 10 µg/dL, where county was known. Montmorency (12/100,000), Cheboygan and Tuscola (5/100,000), had the three highest incidence rates.

Seventeen women (41.5%) with elevated blood lead had their exposure from work: one from a bridge construction company, two from a site preparation company, one from the State Police, one from a brass products manufacturer, one from an electric power generation company, one from an abrasive blasting and painting company, one from academic work at a university, one from being self-employed doing stained glass and historic building restoration, one from industrial painting, three from a sporting goods firing range, two from an electrical equipment wholesaler, one from being self-employed as an artist, and one individual with unknown work exposure.

One woman (2.4%) with an elevated blood lead had her exposure both from work (gun range) and hobby (firearms).

Twenty-three women (56.1%) with elevated blood leads had non-work exposures: ten from firearms, one from pottery making, one from leather tooling, one from home remodeling, five from a gunshot wound, and two from using spices while cooking. The source of exposure was unknown for twenty-four of the 65 women.

Figure 9 **Annual Incidence of BLLs ≥ 10 µg/dL Among Women by County of Residence, Michigan 2012 - 2013**



*Denominator is Rate per 100,000 women age 16+ from US Census Bureau of County Resident Population, Annual Estimate for July 1, 2013

Results, continued

Table 6. Number and Rate of BLLs ≥ 10 µg/dL Among Women in Michigan by County of Residence: 2012 - 2013

County	Number Reported	Michigan Population Women	Rate***
Berrien	2	64,474	2
Calhoun	2	55,480	2
Cheboygan	1	10,888	5
Delta	1	15,370	3
Genesee	3	173,033	1
Grand Traverse	1	37,367	1
Hillsdale	1	18,747	3
Ingham	5	120,281	2
Isabella	1	30,806	2
Jackson	2	63,035	2
Kent	7	247,808	1
Lapeer	1	35,367	1
Lenawee	1	39,691	1
Livingston	4	73,923	3
Macomb	4	358,491	1
Monroe	2	61,440	2
Montmorency	1	4,057	12
Muskegon	1	68,738	1
Oakland	5	515,496	0.5
Saint Clair	2	65,786	2
Shiawassee	1	28,296	2
Tuscola	2	22,167	5
Van Buren	1	30,226	2
Washtenaw	1	149,073	0.3
Wayne	9	735,065	1
Total	**61***	**4,072,780****	**1**

*County was unknown for 4 women.
**Total number of women in all 83 counties of Michigan age 16+ years; 7/1/2013 County Characteristics Resident Population Estimates, U.S. Census Bureau
***Rate per 100,000 women, age 16+ years.

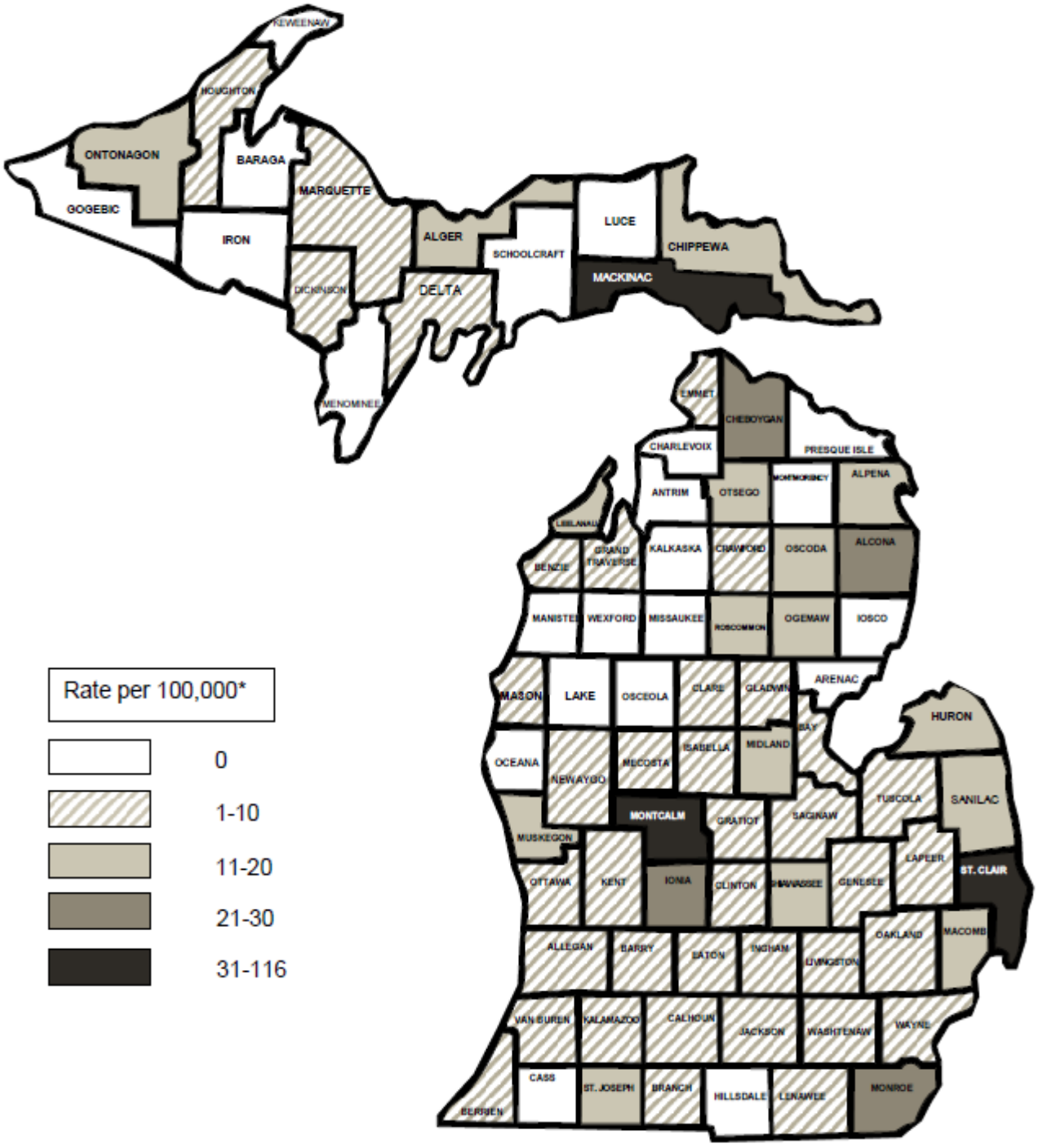
Figure 10 and Table 7 show the incidence rates of BLLs ≥10 µg/dL and above by county for men. There were 753 men reported in 2012-2013 with a BLL ≥ 10 µg/dL where county of residence could be determined. Mackinac (116/100,000), Montcalm (46/100,000) and Saint Clair (44/100,000) had the highest incidence rates per 100,000 men based on the 2013 County Characteristics Resident Population Estimates from the U.S. Census Bureau. The overall incidence rate for men was 10 times higher than that for women (10/100,000 vs. 1/100,000) in 2012 - 2013.

Source of Exposure

For 711 (82.0%) adults with BLLs ≥10 µg/dL, work was the identified source. For 156 (18.0%) adults non-occupational activities were identified as the source of exposure. Table 8 shows the non-work related source of exposure of lead for 156 individuals with BLLs ≥10 µg/dL reported in 2012 and 2013. Of those 156, three non-occupational activities predominated. One hundred and eight (69.2%) individuals were exposed from a hobby related to guns, seventeen (10.9%) were exposed due to a retained bullet fragment and eleven (7.1%) were exposed due to home remodeling. For an additional 68 individuals source of exposure is still being investigated. For 51 the source was still unknown after an interview with the individual or review of medical records.

Results, continued

Figure 10 **Annual Incidence of BLLs ≥ 10 µg/dL Among Men by County of Residence, Michigan 2012 - 2013**



*Denominator is Rate per 100,000 men age 16+ from U.S. Census Bureau of County Resident Population, Annual Estimate for July 1, 2013

Results, continued

Table 7. Number and Rate of BLLs ≥10 µg/dL among Men by County of Residence, Michigan 2012-2013

County	Number Reported	Michigan Population Men	Rate	County	Number Reported	Michigan Population Men	Rate
Alcona	2	4,676	21	Lake	0	4,960	0
Alger	1	4,581	11	Lapeer	5	35,923	7
Allegan	7	43,378	8	Leelanau	2	9,110	11
Alpena	3	11,472	13	Lenawee	8	40,226	10
Antrim	0	9,593	0	Livingston	12	72,823	8
Arenac	0	6,540	0	Luce	0	3,273	0
Baraga	0	4,021	0	Mackinac	11	4,760	116
Barry	2	23,561	4	Macomb	73	330,841	11
Bay	8	42,142	9	Manistee	0	10,757	0
Benzie	1	7,125	7	Marquette	2	28,636	3
Berrien	6	59,677	5	Mason	1	11,450	4
Branch	2	17,814	6	Mecosta	2	17,937	6
Calhoun	7	51,811	7	Menominee	0	9,902	0
Cass	0	20,868	0	Midland	8	32,956	12
Charlevoix	0	10,511	0	Missaukee	0	6,041	0
Cheboygan	5	10,769	23	Monroe	28	58,993	24
Chippewa	5	18,003	14	Montcalm	24	26,146	46
Clare	2	12,470	8	Montmorency	0	4,076	0
Clinton	6	30,041	10	Muskegon	18	65,793	14
Crawford	1	5,878	9	Newaygo	2	19,102	5
Delta	1	14,910	3	Oakland	80	474,313	8
Dickinson	2	10,692	9	Oceana	0	10,345	0
Eaton	8	42,220	9	Ogemaw	2	8,757	11
Emmet	1	13,167	4	Ontonagon	1	2,840	18
Genesee	31	155,701	10	Osceola	0	9,216	0
Gladwin	2	10,538	9	Oscoda	1	3,503	14
Gogebic	0	7,456	0	Otsego	2	9,505	11
Grand Traverse	7	35,820	10	Ottawa	10	103,281	5
Gratiot	2	18,507	5	Presque Isle	0	5,591	0
Hillsdale	0	18,258	0	Roscommon	3	10,297	15
Houghton	1	16,200	3	Saginaw	13	75,523	9
Huron	3	13,226	11	Saint Clair	56	63,427	44
Ingham	13	111,059	6	Saint Joseph	5	23,268	11
Ionia	12	27,668	22	Sanilac	6	16,658	18
Iosco	0	10,698	0	Schoolcraft	0	3,400	0
Iron	0	4,850	0	Shiawassee	8	27,142	15
Isabella	1	28,658	2	Tuscola	2	22,029	5
Jackson	10	65,802	8	Van Buren	4	29,057	7
Kalamazoo	15	100,096	7	Washtenaw	14	142,943	5
Kalkaska	0	7,042	0	Wayne	134	659,990	10
Kent	49	233,516	10	Wexford	0	12,829	0
Keweenaw	0	947	0	**Total**	**753***	**3,849,851****	**10*****

*County was unknown for 168 additional male adults; 4 were out of state residents.
**Total number of men in all 83 counties of Michigan age 16+ years; 7/1/2013 County Characteristics Resident Population Estimates, U.S. Census Bureau; ***Rate per 100,000 men, age 16+

Results, continued

Table 8 Source of Exposure among Adults with BLLs ≥10 µg/dL, Michigan 2012 – 2013

Exposure Source Description	Number	Percent	Percent NonWork
Work-Related*	711	82.0	
Hobby: Firearms, Reloading, Casting	108	12.5	*69.2*
Gun Shot Wound	17	2.0	*10.9*
Remodeling	11	1.3	*7.1*
Lead Paint Ingestion (Pottery, Ceramics, Food)	8	0.9	*5.1*
Hobby: Other	4	0.5	*2.6*
Hobby: Stained Glass	3	0.3	*1.9*
Hobby: Unknown	3	0.3	*1.9*
Other, Not Work	1	0.1	*0.6*
Hobby: Sinkers	1	0.1	*0.6*
Total	867**	100.0	*100.0*

*Work-Related category includes 13 adults, who were exposed to lead from both Work-Related as well as Non-Work related activities.
**For 7 additional adults source is pending an interview and for 61 medical records; for 4 additional adults source was inconclusive based on interview; for 51 additional adults, source was inconclusive and no patient interview was possible.

Table 9 shows the occupational sources of lead for individuals reported in 2012 and 2013. The most frequent reports were on individuals in the construction sector (43.3%) and manufacturing (30.6%).

Figure 11 shows the geographic distribution of the thirty-two non-construction companies that reported at least one adult with a BLL of 25 µg/dL or greater in Michigan during 2012 and 2013. For two additional companies, we were unable to determine the county and one was located

Table 9. Industry Source of Exposure among Adults with BLLs ≥10 µg/dL, Michigan 2012-2013

Exposure Source—Industry (SIC Code)*	Number	Percent
Construction (15-17)	**259**	**43.3**
Painting (17)	*254*	*42.5*
Manufacturing (20-39)	**183**	**30.6**
Fabricated and Primary Metals (33-34)	*152*	*25.4*
Transportation and Public Utilities (40-49)	**44**	**7.4**
Wholesale and Retail Trade (50-59)	**39**	**6.5**
Services (60-89)	**48**	**8.0**
Automotive Repair Services (75)	*5*	*0.8*
Public Administration (91-97)	**25**	**4.2**
Justice, Public Order, Safety (92)	*18*	*3.0*
Total	598**	100.0

*Standard Industrial Classification.
**Another 113 were work-related; however, the industry was unknown.

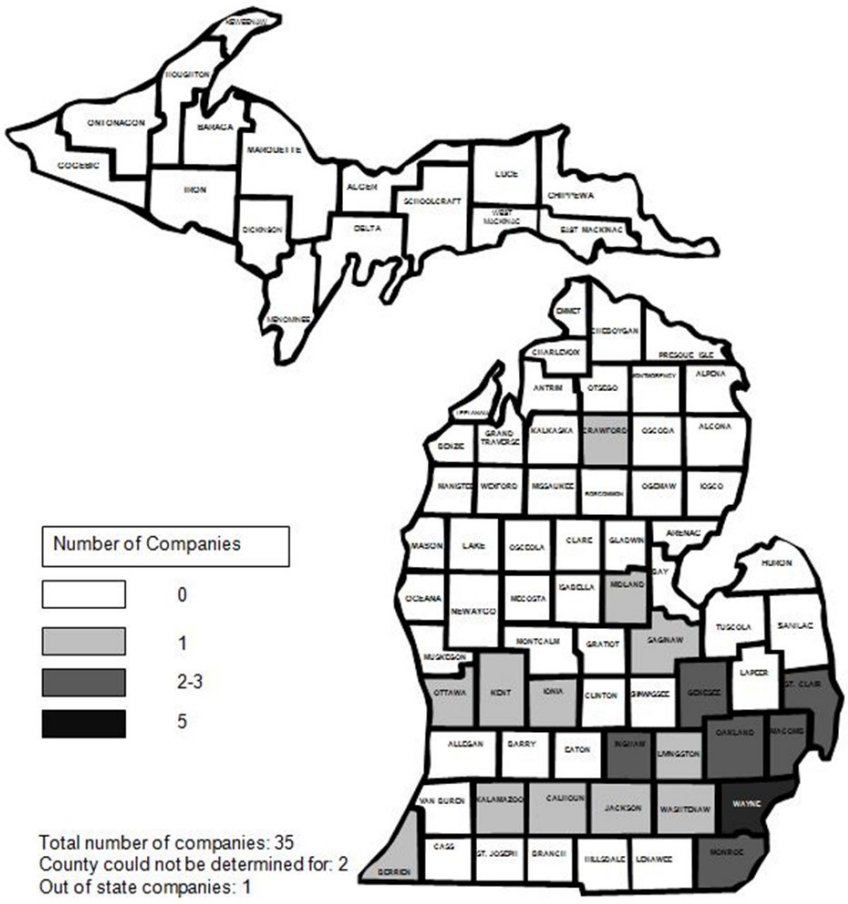
Results, continued

out-of-state. These thirty-five companies included police department shooting ranges, primary metals industries, fabricated metal products, industrial and commercial machinery and transportation equipment, battery recycling, transportation equipment, railroad transportation, motor freight transportation and warehousing, electric services, wholesale trade-durable goods, an auto supply store, radiator repair shops, and firing ranges.

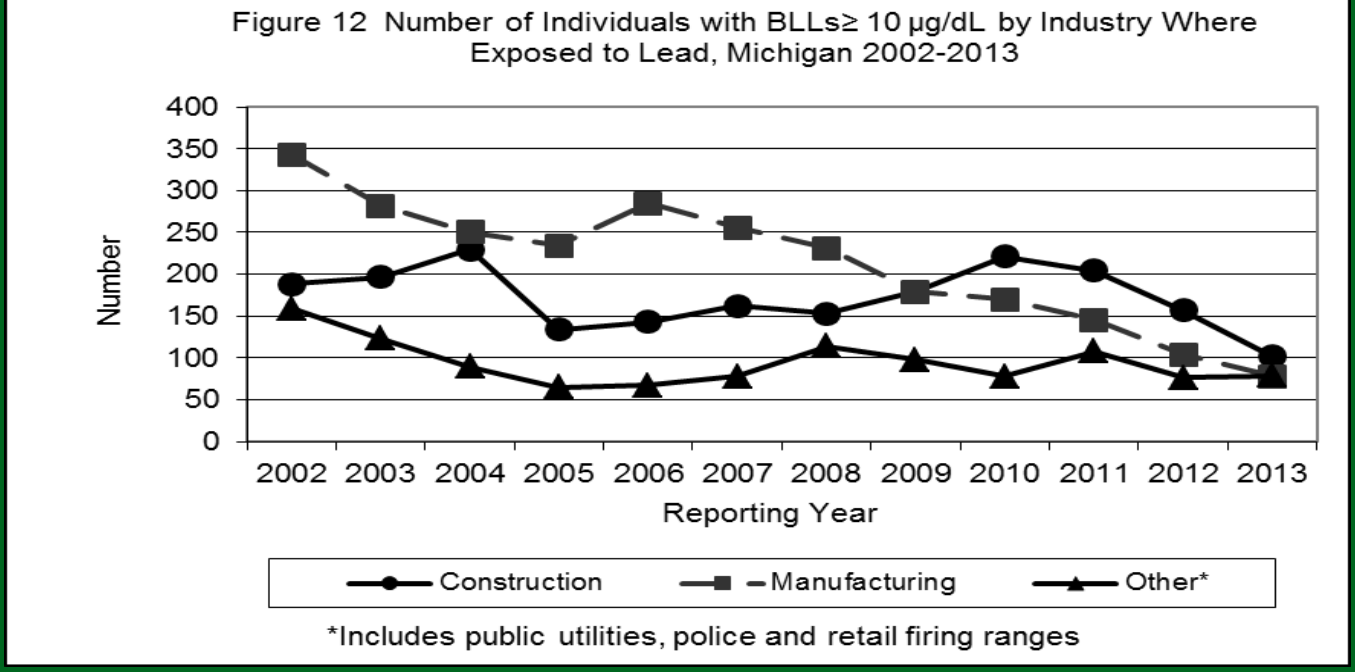
Two hundred and twenty-five (31.6%) of the 711 individuals with a blood lead ≥ 10 µg/dL where exposure occurred at work, and 69 (52.7%) of the 131 individuals with a blood lead ≥ 25 µg/dL were from these thirty-five companies.

The recent elevated BLLs have generally been decreasing across all types of occupational sources. Although some of this reduction is due to improvements in work place controls, some of the decrease is presumed to be secondary to closure of manufacturing facilities using lead. Construction is a more frequent source of lead exposure than manufacturing, and, if the previous trend continues, “Other”, which includes public utilities, police and public firing ranges, will become a more frequent lead exposure source than manufacturing (Figure 12).

Figure 11 Geographic Distribution of Non-Construction Companies Reporting Adult BLLs ≥ 25 µg/dL In Michigan, 2012 - 2013



Results, continued



Industrial Hygiene Inspections Conducted for BLLs ≥ 25 µg/dL, 2012-2013

There were 10 inspections conducted in 2012-2013; two were conducted in the construction industry. The other eight inspections, which were done by the MIOSHA General Industry Division, included a police department firing range, three gun ranges, a plumbing fixture fitting and trim manufacturing facility, a recyclable material merchant wholesaler, a metal storage warehouse and a brass/bronze foundry.

A general industry health inspection was completed in 2012 at an indoor shooting and training facility as a result of an employee with an elevated blood lead level of 35 µg/dL. The facility featured fourteen computerized firing lanes (Picture 1), classroom facilities and a full-service retail firearms store. The company was cited for 6 lead violations and 1 other violation. The lead citations included: MIOSHA monitoring results showed that one employee who cleaned the range trap (Picture 2) was exposed to lead above the permissible exposure limit of 50 µg/m^3 for an 8-hour work shift— the employee was exposed to a lead level of 1,859 µg/m^3 during an 8-hour work shift; the employer did not determine if an employee might have been exposed to lead at or above the action level; a written compliance program was not established and implemented to reduce exposures to at or below the permissible employee exposure limit solely by means of engineering and work practice controls; a respiratory protection program was not implemented for employees required to wear respiratory protection; the employees were not informed of the contents of Appendices A and B of the MIOSHA standard; and a training program was not instituted for all employees who were subjected to exposure to lead at or above the action level or for whom the possibility of skin or eye irritation existed from exposure to lead.

Industrial Hygiene Inspections, continued

Picture 1
14 Computerized
Firing Lanes

Picture 2
Range Trap behind
14 Computerized
Firing Lanes

Industrial Hygiene Inspections, continued

A general industry health inspection was completed in 2012 at a plumbing fixture fitting and trim manufacturing company as a result of an employee with a blood lead level of 29 µg/dL. Lead is a component of the forged fixture pieces that are manufactured at this company. The company was cited for one non-lead violation: the company did not verify through a written certification that the required workplace hazard assessment had been performed that employees are required to wear safety glasses on the production floor.

A general industry health inspection was completed in 2012 at a recyclable material merchant wholesaler based on a laboratory report that indicated that an employee might be bringing lead from the workplace to their home through contaminated clothing. During the inspection it was indicated that large pieces of scrap metal were accepted that may have had paint or primer that contained lead. Employees torch-cut these large pieces so that they fit into shipping trucks. Air monitoring was conducted on one employee who was torch-cutting and no lead was detected. During inspection it was also noted that the employer accepted scrap lead in the form of dead car batteries, radiators, and spent bullets. Handling of lead by employees included stacking dead batteries as they were received on pallets. Employees were provided with gloves. Wipe samples taken in the shipping area, lunch room, and locker room did not reveal the presence of lead. The inspection found no violations.

A general industry health inspection was completed in 2012 at a gun range as a result of an employee with a blood lead level of 25 µg/dL. The company was cited for one non-lead violation: noise monitoring conducted during the inspection demonstrated that employees were exposed above the action level.

A general industry health inspection was completed in 2012 at a police department firing range as a result of an employee with a blood lead level of 25 µg/dL. Over 60 police personnel were required to qualify quarterly for firearms usage. Personnel spent approximately two hours per month at the range. Range officers spent less than six hours a month at the range. Homeland Security, border patrol had been renting the facility five days a week, sixteen hours per day. The type of bullet trap used at the facility was shredded rubber (Picture 3). An outside company was contracted to clean the trap. The company was cited for two lead and two non-lead violations: the employer did not determine if employees might have been exposed to lead at or above the action level; police personnel were not provided with Appendices A and B Part 310, Lead; the employer did not develop, implement, and maintain a hazard communication program; the employer did not develop and implement a noise monitoring program to determine if employees' exposure equaled or exceeded the action level.

A construction inspection was completed in 2012 at a painting/bridge painting/sandblasting company (Picture 4) as a result of an employee with a blood lead level of 36 µg/dL. The company was cited for seven lead and three non-lead violations: the employer used dry sweeping and shoveling of lead contaminated debris during containment cleanup where vacuuming was feasible; lack of clean change areas for employees whose airborne exposure to lead was above the permissible exposure limit, without regard to the use of respirators; the employer did not assure that employees showered at the end of the work shift; an adequate supply of cleansing agents and towels were not provided for use by affected employees; the employer failed to provide adequate hand washing facilities for use by employees; the employer did not post a sign in the area where employees' exposure to lead was above the PEL; the employer did not ensure that employees perform a user seal check each

Industrial Hygiene Inspections, continued

Picture 3

Target and Bullet Trap with Shredded Rubber

Picture 4

Abrasive Blasting of Structural Steel Coated with Lead-Containing Paint

Industrial Hygiene Inspections, continued

time they put on a tight-fitting respirator; the employer did not ensure that the compressor used to supply breathing air to respirators had a tag containing the most recent change date (for sorbent beds and filters) and the signature of the person authorized by the employer to perform the change; and the employer did not ensure that oil-lubricated compressors utilized to produce breathing air used a high-temperature or carbon monoxide alarm, or both, to monitor carbon monoxide levels. The employer did not initially determine if any employee performing abrasive blasting of structural steel coated with paint containing lead may be exposed to lead at or above the action level of 30 µg/m^3 – this was a repeat violation for the company which has been previously cited for a violation of this occupational and health standard, Part 603.

A general industry health inspection was completed in 2013 at a gun range as a result of an employee with a blood lead level of 25 µg/dL. The company was cited for eleven lead and one non-lead violations: employees cleaning the firearms range were exposed to inorganic lead concentrations exceeding the Permissible Exposure Limit (PEL) of 50 µg/m^3 (Pictures 5 and 6); the employer did not perform representative monitoring to determine if an employee might be exposed to airborne concentrations of inorganic lead; a written compliance program was not established and implemented to reduce exposures to at or below the permissible employee exposure limit solely by means of engineering and work practice controls; the employer did not implement a respiratory protection program; the employer did not provide medical evaluations to affected employees before requiring employees to use the respirator in the workplace; wipe sampling results indicated that excessive accumulations of inorganic lead were found on various work surfaces; employees performing cleaning of the firearms range were not provided with a clean change room; employees performing cleaning of the firearms range were not provided with shower facilities; employees performing cleaning of the firearms range were not required to wash contaminated skin prior to eating, drinking, or smoking; the employer did not provide specific information contained in Appendix A & B of the standard to employees working inside the firearms range (Range Safety Officer, Firearms Instructors) and those who perform cleaning activities (laborers); the employees were not provided with a lead hazard training program that met the requirements of Rule 49 (a training program was not instituted for all employees who were subjected to exposure to lead at or above the action level or for whom the possibility of skin or eye irritation existed from exposure to lead); and the firearms range and the firearms range exhaust ventilation system did not have a warning sign posted: WARNING; LEAD WORK AREA; POISON; NO SMOKING OR EATING.

A construction inspection was completed in 2013 at a site of work being performed by a highway and bridge construction company as a result of an employee with a blood lead level of 58 µg/dL. The company was sandblasting the north end of the Mackinac Bridge. During the investigation it was determined that abrasive blasting work has been performed at the site. At the time of the investigation, all abrasive blasting activities had been completed. The investigation reviewed the procedures used during the abrasive blasting activities. The company was cited for one lead and one non-lead violations: the employer did not make available upon request all records for examination and copying; and the employer failed to provide within four business hours copies of requested records.

Industrial Hygiene Inspections, continued

Pictures 5 & 6

Employees Cleaning Firearms Range

Industrial Hygiene Inspections, continued

A general industry health inspection was completed in 2013 at a metal storage warehouse as a result of an employee with repeat blood lead levels of 27, 65, 69, 68, 41 and 37 µg/dL in a calendar year. Warehouse workers were exposed to lead dust from raw materials and old lead paint throughout the warehouse. The appropriate personal protective equipment was not provided by the employer nor were employees required to wear protective equipment. Employees became covered in lead-containing dust which was brushed off at the end of the work day using a steel brush. The company was cited for nine lead violations: forklift operators and general laborers were exposed to lead from the transportation and storage of bulk lead castings (Picture 7) and the deterioration of lead-containing paint that covered the building's interior walls and ceiling; appropriate protective work clothing and equipment was not provided, at no cost to the employee, and its use was not ensured, when an employee was exposed to lead above the permissible employee exposure limit without regard to the use of respirators, or if the possibility of skin or eye irritation existed; surfaces in a workplace were not maintained as free as practicable from accumulations of lead; vacuuming or other equally effective methods were not used in removing lead accumulations; employees whose work caused significant hand or face lead contamination were not required to wash the contaminated skin areas prior to applying cosmetics, eating, drinking, or smoking; a medical surveillance program was not instituted for each employee who was or may have been exposed to concentrations of lead greater than the action level for more than 30 days a year; in a workplace in which there was a potential exposure to airborne lead at any level, the employees were not informed of the contents of Appendices A and B of Part 310; a training program was not instituted for all employees who were subjected to exposure to lead at or above the action level or for whom the possibility of skin or eye irritation existed from exposure to lead; and a copy of these rules and their appendices were not made readily available to all affected employees.

A general industry and health inspection was completed in 2012 at a brass/bronze foundry as part of a special project with the brass/bronze industry initiated in 2009. The company was cited for two lead and sixteen non-lead violations: a training program was not instituted for all employees who were subject to exposure to lead at or above the action level or for whom the possibility of skin or eye irritation existed from exposure to lead: foundry employees were exposed to lead and skin or eye irritation existed; in a workplace or work operation subject to Part 310, the employer did not determine if an employee might have been exposed to lead at or above the action level: foundry employees were exposed to lead (Picture 8); the employer did not ensure that each container of hazardous chemicals in the workplace was labeled, tagged, or marked with the appropriate hazard warnings: Employees use Olivine LE 75 (mold sand): the bag was not labeled with a hazard warning; employees were not provided effective information and training on hazardous chemicals in their work area at the time of their initial assignment: an employee who was exposed to hazardous chemicals in the workplace (such as silica) was not provided information and training at the time of initial job assignment; a medical evaluation, to determine the employee's ability to use a respirator before the employee was fit-tested or required to use the respirator in the workplace, was not provided: an employee was issued and required to use a half mask elastomeric air purifying respirator with no medical evaluation; an employee using a tight-fitting face piece respirator was not fit tested at least annually after the initial fit test prior to initial use of the respirator, or whenever a different respirator face piece (size, style, model, or make) was used: a new hire employee was issued and was required to use an elastomeric air purifying respirator and was not provided an initial respirator fit test,

Industrial Hygiene Inspections, continued

Picture 7

Storage of Bulk Lead Castings

Picture 8

Brass/Bronze Foundry Employee Exposed to Lead Fume

Industrial Hygiene Inspections, continued

and employees were required to use elastomeric half face air purifying respirators and had not been fit tested annually; training was not provided prior to requiring employees to use a respirator in the workplace: a new hire employee was issued and required to use an elastomeric half face air purifying respirator and was not trained; respiratory protection training was not conducted annually; employees were required to use elastomeric air purifying respirators and were not trained annually; each employee who was required to use personal protective equipment was not trained: a new hire employee who used personal protective equipment was not trained (provide training to include all of the following: when and why personal protective equipment is necessary; what personal protective equipment is necessary; how to properly don, doff, adjust, and wear the personal protective equipment; the limitations of the personal protective equipment; the proper care, maintenance, useful life, and disposal of the personal protective equipment); it was not ensured 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, and (f) radiation: the employer did not ensure the grinder operator used appropriate eye protection when exposed to flying particles; at least annually after obtaining the baseline audiogram, a new audiogram was not obtained for each employee exposed at or above the action level: an employee was exposed to noise above the action level and a new audiogram was not obtained at least annually; copies of noise rules were not made available to affected employees and also a copy was not posted in the workplace: an employee was exposed to noise above the action level and the employer did not post a copy of the noise standard in the workplace; the written hazard communication program did not include the methods the employer will use to inform employees of the hazards of non-routine tasks: the employer's written hazard communication program did not address the methods the employer will use to inform employees of the hazard of the non-routine task and associated chemicals hazards; the employer did not have a material safety data sheet for each hazardous chemical which they used: employees use Graphite No. 2, and Concrete Bonding Adhesive, and the employer did not have MSDSs for these chemicals; the locations of the material safety data sheets for the hazardous chemicals used in the workplace and the name of the person from whom to obtain the sheets was not provided; evaluations of the workplace were not conducted to ensure the written respiratory protection program was being effectively implemented: employees were required to use elastomeric half face air purifying respirators and the employer did not evaluate the effectiveness of the respirator program; and it was not verified, through a written certification that was identified as a certification of hazard assessment, that the required workplace hazard assessment had been performed: the employer's personal protective equipment hazard assessment did not include the person certifying that the evaluation has been performed and the date of the hazard assessment.

All of the ten companies inspected were identified by an elevated blood lead report collected because of a required medical surveillance program.

Case Narratives: 18 Individuals with a BLL ≥50ug/dL in 2012-2013

Work-Related (11 Individuals)

- A male in his mid-50s employed at a police department had an elevated BLL of 50 µg/dL in February 2012. The employee was involved in a cleanup of a firing range.
- Two men employed at an indoor shooting range had elevated BLLs. The first employee, in his mid-20s, had an elevated BLL of 58 µg/dL in January 2012. The second employee, also in his mid-20s, had an elevated BLL of 52 µg/dL in February 2012.
- A male in his 40s employed at an indoor shooting range had an elevated BLL of 77 µg/dL in March 2013.
- A male in his mid-30s, employed as a hi lo driver at a metal storage warehouse, had an elevated BLL of 69 µg/dL in August 2013. He reported that the warehouse stored aluminum, aluminum alloys, zinc and lead, which were stacked from the floor to the ceiling.
- Two men employed at an industrial painting company had elevated BLLs. The first employee, a male in his 40s, had an elevated BLL of 58 µg/dL in August 2013. The employee's job assignment was to sandblast lead paint off the Mackinac Bridge. The second employee, a male in his mid-40s, had an elevated BLL of 51 µg/dL in August 2013. The Ohio State Health Department received BLLs of OH residents working on the Mackinac Bridge that ranged from 15 to 75 µg/dL.
- A female in her mid-40s, employed as a Professor of Arts at a university, had an elevated BLL of 57 µg/dL in September 2013, presumably secondary to the use of scrap metal pieces that had been painted with lead paint
- A male in his late 30s employed at a hazardous waste treatment and disposal company had an elevated BLL of 61 µg/dL in October 2013. His job was to go to shooting fields or target practice fields and recover all the lead bullet pellets and to grind those up into a machine that separates the dirt from the lead.
- A male in his mid-50s employed with a heating and air conditioning contractor had an elevated BLL of 51 µg/dL in November 2013**.**
- A male in his mid-60s, diagnosed with lead toxicity in 2009, continued to have a high BLL, 64 µg/dL in 2012. His exposure to lead was suspected to be from several sources which include both self-employment in renovation of older homes and retained bullet fragments. In August 2009 he reported that doctors removed all operable bullet fragments. His highest BLL of 144 µg/dL was in January 2009. His lowest level of 52 µg/dL was in April 2010. He also reported discontinuation of all renovation and work activities due to his failing kidney function and overall health. Contact had been made with the Detroit Health Department for further investigation of possible sources.

Non Work-Related (7 Individuals)

- A male in his mid-60s had an elevated BLL of 54 µg/dL in September 2013. His exposure to lead was from firearms target practice and cleaning a shooting range.

Case Narratives: 18 Individuals with a BLL ≥50ug/dL in 2012-2013, continued

- A male in his 50s had an elevated BLL of 51 µg/dL in December 2013. His exposure to lead was from firearms target practice that he has been doing for 15 years. He has also volunteered to clean out traps at the shooting range.
- A male in his mid-30s had an elevated BLL of 160 µg/dL in February 2012 because of a gunshot wound. In June 2013, his BLL dropped but was still high at 69 µg/dL.
- A female in her 60s had an elevated BLL of 128 µg/dL in November 2012. Her elevated BLL was caused by retained bullet fragments.
- A female in her mid-50s had multiple elevated BLLs with the highest BLL of 155 µg/dL in February 2012. In December 2013, the highest BLL she had was 63 µg/dL. Her elevated BLL was caused by retained bullet fragments.
- A male in his mid-40s had an elevated BLL of 60 µg/dL in September 2012. His exposure to lead was from remodeling work he had done on his home.
- A male in his late 30s had an elevated BLL of 84 µg/dL in November 2012. The source of exposure could not be determined. An interview could not be successfully completed because the patient was incarcerated.

Fifteen Years of Interviews of MI Adults with BLLs of ≥ 10 µg/dL: Children's Potential Exposure to "Take Home" Lead

Between October 15, 1997, and December 31, 2013, 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 (6 or under) potentially exposed to take home lead from adults with BLLs ≥ 10 µg/dL. That table has been updated with 16 interviews (Table 10) completed in 2012-2013.

Five hundred and seventeen (24.8%) 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 10). Children from only 149 (33.3%) of these 517 households were tested for blood lead. Among the 149 households where the child's blood test results were reported, 48 (34.3%) 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 10 Number 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 12/31/2013

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	300	23.5	74	26.2	95	27.7	31	27.2	11	26.8	6	25.0	517	24.8
Households with Children Tested for Lead	92	36.5	17	26.2	21	24.1	14	50.0	4	36.4	2	40.0	149	33.4
Households Where Children had Elevated Lead	27	31.4	3	18.8	9	42.9	7	58.3	1	33.3	1	50.0	48	34.3

*Among individuals within blood lead category, percentage of their households with children living or spending time in house. n=2,081

**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=446

***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=140

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 reported is ≥ 16 years of age, 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, and individuals with BLLs of 10-24 µg/dL where the lead exposure source is not already known, are contacted by mail and then 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 2012 - 2013, there were 990 adults with BLLs ≥ 10 µg/dL. Approximately 58% were men. The mean age was 44.8. They were predominately white (84.4%) and lived in a band of counties stretching across the southern part of the state from Muskegon to St. Clair. The source of exposure to lead was predominately occupational in origin (81.0%). Exposure occurred during demolition of lead painted metal structures and abrasive blasting to remove paint or during the fabricating of non-ferrous metal parts and metal products.

Discussion, continued

In 2012 - 2013 eighteen Michigan adults were reported with BLLs greater than or equal to 50 µg/dL, the maximum blood lead level allowed in the workplace. Ten of the eighteen adults were exposed to lead exclusively at work (four from shooting ranges, including one police officer involved in a clean-up of a firing range), two from an industrial painting company, one from being employed as a hi-lo driver at a metal storage warehouse, one from art projects at a university, one from recovering and subsequent grinding lead bullet pellets from outdoor firing ranges, and one from being employed as a heating and air conditioning contractor. A retained bullet from a gunshot wound and self-employment doing demolition activities were the source of lead exposure for the tenth individual. There were six individuals with non-work exposure to lead; two individuals were doing competitive shooting; one was remodeling their home, and three had retained bullet fragments. The source of exposure that caused an elevated blood lead level in the eighteenth individual could not be determined.

Lead exposure remains an important public health concern in the United States 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, have greatly reduced exposure to lead in the general population. Average BLLs in the general population have dropped from 15 ug/dL in the 1970s to the current .973 µg/dL (1).

Occupational exposure has not declined as much as environmental lead exposure. Data from 41 state lead surveillance systems shows that nationally, approximately 95% of adult elevated lead exposure is work-related (3). 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.

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 (4-7). Levels as low as 5 ug/dL have been associated with adverse cardiovascular and neurologic health effects (4, 7).

Both the International Agency for Cancer (IARC) and the National Toxicology Program have classified lead to be a probable human carcinogen (8, 9), 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 (3), making both mortality from stroke and heart disease outcomes of interest. High lead exposure is known to cause non-malignant kidney disease (10), but it is not known if lower levels contribute to this outcome.

Discussion, continued

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 have lowered the upper limit of normal to 10 µg/dL. Given the recent decision by 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 health care providers who ordered the blood lead needs to be compatible with these recommendations since laboratory reports are often their main source of information (11), http://c.ymcdn.com/sites/www.cste.org/resource/resmgr/OccupationalHealth/ManagementGuidelinesforAdult.pdf). 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 2001-2012 was 3.36 µg/dL (2.98-3.93)(1).

Although the major source of lead exposure to children is living in housing built before 1978 with 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 the work clothes, and provide showering facilities and clean and dirty change rooms for lead-exposed employees to reduce take-home exposure to the families of lead-exposed workers. To assure that these actions are being performed and are adequately protective, it is important that workers who have children six years or younger who live or frequently visit their home assure that these children are tested for lead. Unfortunately, this is not happening; only one in three families with an adult exposed to lead at work report that their young children are tested for elevated lead. When these children are tested, 33% are found to have an elevated blood lead level (Table 10). This is a much higher percentage of elevated blood lead levels than found among all children tested for blood lead in the state (0.4%). 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 sixteenth year of operation, the surveillance system for lead continued to prove successful in identifying large numbers of adults with elevated lead levels and sources of exposure that could be remediated to reduce exposures in Michigan. The reduction in the number of individuals with elevated blood lead levels, particularly from occupational exposures, has declined (Figures 3-5).

Discussion, continued

Continued outreach is planned to the medical community on the recognition and management of potential lead-related medical problems in both individuals and their young families. Both California and Washington have initiated the process of reducing the allowable workplace lead level. A new more protective OSHA PEL, substitutes of safer compounds, along with expanding education and outreach for employers and workers and their families, would all contribute to lower blood lead levels. Ongoing surveillance in future years will continue to target and evaluate intervention activity to reduce exposure to lead.

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Appendices

Appendix A Elevated Blood Lead Levels Among Employed Adults – United States, 1994 – 2012. Morbidity and Mortality Weekly Report October 23, 2015

Appendix B Summary of Michigan's Occupational Lead Standards

Appendix C Table 1: Health Based Management Recommendations for Lead Exposed Adults, Environmental Health Perspective Vol. 115, No. 3 March 2007.

APPENDIX A

Morbidity and Mortality Weekly Report

Elevated Blood Lead Levels Among Employed Adults — United States, 1994–2012

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Preface

The 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 blood lead levels among employed adults in the United States for 1994–2012. This report is a part of the first-ever *Summary of Notifiable Noninfectious Conditions and Disease Outbreaks*, which encompasses various surveillance years but is being published in 2015 (*1*). The *Summary of Notifiable Noninfectious Conditions and Disease Outbreaks* appears in the same volume of MMWR as the annual *Summary of Notifiable Infectious Diseases* (*2*).

Background

Since 1987, the National Institute for Occupational Safety and Health (NIOSH) and state health departments have maintained a state–based surveillance program of laboratory-reported adult blood lead levels (BLLs) known as the Adult Blood Lead Epidemiology and Surveillance (ABLES) Program (*3*). The BLL is an often-used estimate of recent external exposure to lead (*4,5*). This report summarizes data on elevated blood lead levels among employed adults, defined as persons aged ≥16 years, during January 1, 1994–December 31, 2012.

Reported cases of elevated BLLs in 2012 are provided in tabular form (Tables 1–4). 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 who reside in another state) and "state-residents" only, by exposure source, age, and sex groups, for BLLs ≥10 μg/dL (current definition of elevated BLL) (*3,6*), and for BLLs ≥25 μg/dL (former definition of elevated BLL)(*7*). The current case definition was adopted in 2009 on the basis of mounting evidence for adverse health outcomes among adults with BLLs between 10 μg/dL and 25 μg/dL (*4,6*). State prevalence rates of elevated BLLs (≥10 μg/dL) for 2012 are categorized into two groups (above or below the national rate) (Figure 1). Trends of national prevalence rates of BLLs ≥10 μg/dL and BLLs ≥25 μg/dL from 1994 to 2012 are provided (Figure 2). Prevalence rates are provided for "all cases" (these include cases among adult residents in the reporting state plus cases identified by the reporting state but who reside in another state) and "state-residents" when available. National and state numbers of cases, employed populations, and prevalence rates of elevated BLLs are provided in tabular form (Tables 5–10). Available data include BLLs ≥10 μg/dL from 2010 to

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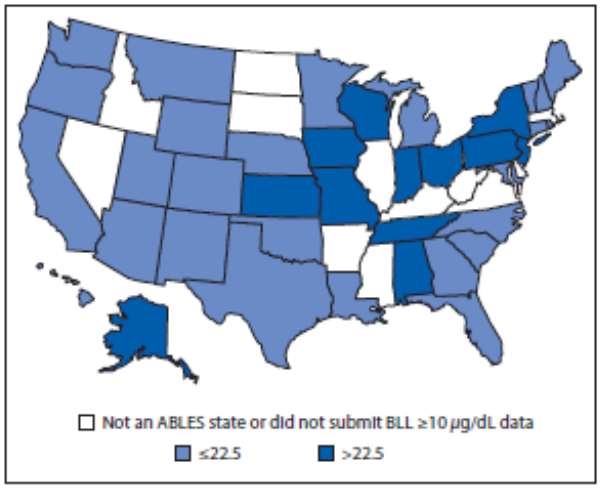
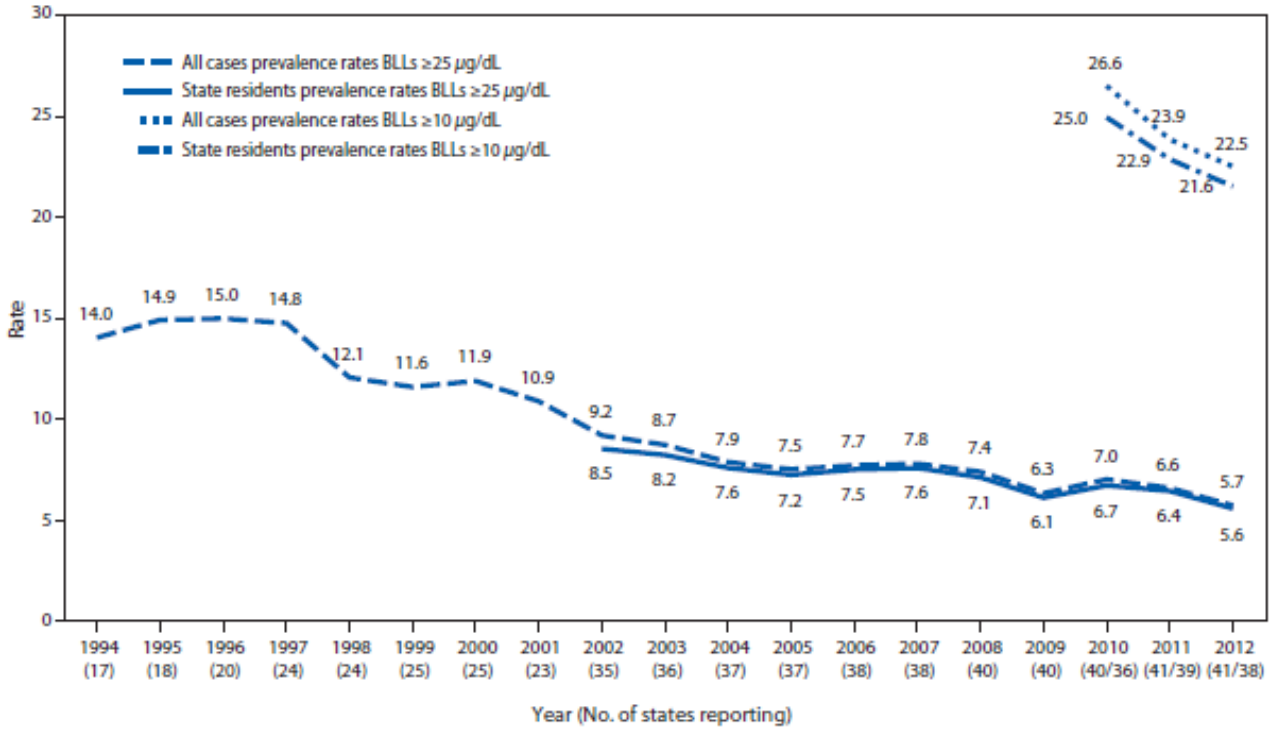
FIGURE 1. Prevalence rate* of adults with elevated blood lead levels ≥10 μg/dL, by state — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012†



Abbreviation: ABLES = Adult Blood Level Epidemiology and Surveillance.
* Rate per 100,000 employed adults aged ≥16 years. State-resident rate might be lower for some states. Data from the Adult Blood Epidemiology and Surveillance Program, National Institute for Occupational Safety and Health (NIOSH/CDC). Denominators for 2012 extracted from 2013 U.S. Department of Labor, Bureau of Labor Statistics, Local Area Unemployment Statistics (LAUS) program available at http://www.bls.gov/lau/staadata.txt.
† A total of 41 states submitted data in 2012: Alabama, Alaska, Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Washington, Wisconsin, and Wyoming. Kentucky and Illinois submitted BLLs ≥25 μg/dL and Massachusetts submitted BLLs ≥15 μg/dL. In 2012, the two states reporting the highest prevalence of elevated blood lead levels were Missouri (106.66) and Kansas (77.32). The national rate in 2012 was 22.5 cases per 100,000 employed adults aged ≥16 years.

FIGURE 2. National prevalence rate* of reported cases of elevated blood lead levels (BLLs),† by year — State Adult Blood Epidemiology and Surveillance Programs, United States, 1994–2012§



Abbreviations: All cases = all reported cases by a state, including adult residents in the reporting state and residents in other states; state residents = adult residents in the reporting state.

* Per 100,000 employed adults aged ≥16 years. Denominators for 1994–2012 extracted from 2013 US Department of Labor, Bureau of labor Statistics Local Area Unemployment Statistics (LAUS) program available at 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.

§ Numbers of states reporting BLL ≥25 µg/dL data are in parentheses. From 2010, numbers of states reporting BLLs ≥10 µg/dL data also are provided. A total of 41 states submitted data in 2012: Alabama, Alaska, Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Washington, Wisconsin, and Wyoming.

2012 and BLLs ≥25 µg/dL from 1994 to 2012. Prevalence rates and numerators are provided for "all cases" and "state residents" when available. The number of employed adults (state residents) used as denominators for calculating rates are provided in tabular form (Tables 11 and 12).

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 (*8*). To accomplish this objective, OSHA utilized ABLES data to identify industries with elevated BLL problems and has agreements with State ABLES programs to obtain their lead exposure data to target workplace inspections.

Although federal funding for State ABLES programs was discontinued in September 2013, a total of 34 states continue to collaborate with NIOSH (down from a peak of 41). These states self-fund their ABLES programs to sustain lead exposure surveillance and prevention activities. To assist with accomplishing these objectives, State ABLES programs share resources with two other CDC programs: the Healthy Homes and Childhood Lead Poisoning Prevention Program and Environmental Public Health Tracking. 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 ongoing analyses of ABLES data.

The BLL is a direct index of a worker's recent 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 about 40 days in men (*9*), 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 <5 years is measured as incidence because these young children have little lead 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 improved protection from occupational lead exposure. As a result, there is an overall decreasing trend in the prevalence of elevated BLLs among adults. Nonetheless, lead exposures continue to occur at unacceptable levels (*3*). In 2012, the prevalence rate of BLLs ≥10 μg/dL was 22.5 adults per 100,000 employed population. During 2011–2012, the mean BLL in adults in the United States was 1.09 μg/dL (*10*).

Research continues to find that low BLLs are associated with harmful effects in adults (*11*). In 2009, NIOSH and State ABLES programs led the occupational safety and health community to establish a new case definition for an elevated BLL (i.e., BLLs ≥10 μg/dL) (*3*). The Council of State and Territorial Epidemiologists also recommended that CDC use this case definition (*12*). In 2010, for the first time, CDC included elevated BLLs, defined as those ≥10 μg/dL, in the List of Nationally Notifiable Noninfectious Conditions (*6*). The U.S. Department of Health and Human Services' *Healthy People 2020* initiative also uses the 10 μg/dL level for its Occupational Safety and Health Objective No. 7 (OSH-7), which is to reduce the proportion of persons who have elevated blood lead concentrations from work exposures (*13*). Before 2009, the case definition for an elevated BLL was ≥25 μg/dL.

Data Sources

The ABLES program is an occupational health state-based surveillance system. The number of cases (numerator) is provided by 41 State ABLES programs. 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 (available at http://www.bls.gov/data). A direct link to annual averages of states employment status of the civilian noninstitutionalized population is available at http://www.bls.gov/lau/staadata.txt).

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 to 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. NIOSH conducts data quality control, analyzes the data, and disseminates the findings among stakeholders.

Interpreting Data

The primary measure of adult lead exposure in the United States is the National Prevalence Rate of Elevated BLLs. 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. The results indicate that efforts to reduce the prevalence of elevated BLLs have resulted in considerable progress towards reducing lead exposures. However, the ABLES data from 2012 establish that lead exposure remains a national health problem and that continued efforts to reduce lead exposures both within and outside the workplace are needed.

Many adults in the United States continue to have BLLs above levels 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 lower, and increased risk of hypertension and essential tremor at BLLs below 10 μg/dL (*11*).

Prevalence rates of adults with BLLs ≥25 μg/dL are available since 1994. Beginning in 2002, State ABLES programs reported individual BLL laboratory test and state of residence. Formerly, state-resident and non-resident data could not be

separated. When an adult has multiple blood lead tests in a given year, only the highest blood lead level for that adult in that year was counted. Prevalence rates of BLLs ≥10 μg/dL are provided since 2010. Prevalence rates of BLLs ≥25 μg/dL are a subset of rates of BLLs ≥10 μg/dL. In the U.S. most lead exposures are occupational. Among all participating states in 2012, when an exposure source was known, the proportion of BLLs ≥25 μg/dL from occupational exposures was 93.3%. The greatest proportions of adults with elevated BLLs were employed in four main industry sectors: manufacturing, construction, services, and mining.

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

- not all states are included in the system;
- 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, we strongly recommend contacting the State ABLES program investigator. Their contact information is available from the ABLES State-based Programs webpage (http://www.cdc.gov/niosh/topics/ABLES/state.html).

Methods for Identifying Elevated BLLs Among Employed Adults

A nationally reportable case of an employed adult with an elevated BLL is defined as a case in an employed adult (≥16 years at the time of blood collection) with a venous blood lead level ≥10 μg/dL (0.48 μmol/L) of whole blood. The standardized diagnostic test is the blood lead level 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 only BLLs ≥40 μg/dL (*3*). The ABLES program ultimately aims to collect a complete list of variables for all BLL tests, including BLLs <10 μg/dL, and encourages all states to supply this information to NIOSH.

Publication Criteria

Adult cases meet the publication criteria if between 1994 and 2012 a venous BLL was ≥25 μg/dL and since 2010 if the venous BLL was ≥10 μg/dL. BLLs ≥25 μg/dL are a subset of BLLs ≥10 μg/dL and are included for historical comparison. 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.

Highlights

In 2012, a total of 41 states submitted data on 7,529 adults with BLLs ≥25 μg/dL and 38 states submitted data on 27,218 adults with BLLs ≥10μg/dL. Overall, the prevalence of BLLs ≥10 μg/dL among state residents and nonresidents declined from 26.6 adults per 100,000 employed in 2010 to 22.5 in 2012. The prevalence of BLLs ≥25 μg/dL among state residents and nonresidents declined from 14.0 adults per 100,000 employed in 1994 to 5.7 in 2012. In 2012, state prevalence rates of BLLs ≥25 μg/dL were above the national rate (5.7/100,000) in 10 states and state prevalence rates of BLLs ≥10μg/dL were above the national rate (22.5/100,000) in 12 states.

In 2012, more than half (53.0%) of adults with BLLs ≥10 μg/dL were aged 40–64 years 33.3% were aged 25–39 years, and the great majority (91.5%) were males. Historically, in the United States, most lead exposures have been occupational. During 2002–2012, the annual proportion of BLLs ≥25 μg/dL from occupational exposures was 94.7% among participating states (minimum: 93.3% in 2012; maximum: 95.5% in 2004). In 2012, among the 37 states that reported the exposure source for adults with BLLs ≥25μg/dL, the proportion of occupational cases ranged from 38.9% to 100%.

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TABLE 1. Reported numbers of cases 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, 2012†

Division/Area	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
Total	**131,879**	**27,218**	**26,034**	**7,529**	**7,332**
New England					
Connecticut	1,731	281	276	53	53
Maine	656	133	133	18	18
Massachusetts	3,235	—††	—	124	117
New Hampshire	702	155	155	16	16
Rhode Island	501	104	104	22	22
Vermont	338	47	47	8	8
Mid Atlantic					
New Jersey	4,137	1,102	1,085	178	176
New York	8,806	2,149	1,924	285	260
Pennsylvania	5,954	3,138	3,137	1,708	1,708
East North Central					
Illinois	5,982	—	—	318	312
Indiana	2,912	1,081	1,081	280	280
Michigan	4,244	631	630	132	132
Ohio	5,317	2,323	2,167	517	495
Wisconsin	2,850	708	708	100	100
West North Central					
Iowa	1,577	816	816	196	196
Kansas	1,401	1,083	1,083	234	234
Minnesota	2,795	493	493	123	123
Missouri	2,787	2,973	2,973	669	669
Nebraska	979	168	168	51	51
South Atlantic					
Florida	8,547	1,273	1,197	384	363
Georgia	4,342	745	743	205	203
Maryland	2,910	273	253	63	61
North Carolina	4,271	277	274	112	112
South Carolina	1,989	291	290	66	66
East South Central					
Alabama	2,010	970	969	380	380
Kentucky	1,900	—	—	138	122
Tennessee	2,846	985	838	214	195
Louisiana	1,944	382	381	67	67
Oklahoma	1,698	175	117	80	65
Texas	11,762	1,149	1,144	261	260
Mountain					
Arizona	2,774	238	238	43	43
Colorado	2,531	107	69	44	37
Montana	477	27	27	2	2
New Mexico	860	50	50	7	7
Utah	1,303	164	56	26	8
Wyoming	289	56	55	12	12
Pacific					
Alaska	340	219	139	30	23
California	16,590	1,797	1,783	221	218
Hawaii	612	28	27	2	2
Oregon	1,777	344	226	53	38
Washington	3,203	283	178	87	78

* A 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.

† A total of 41 states participated in the ABLES Program in 2012.

§ Adults with BLLs ≥25 µg/dL are a subset 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. States did not report this variable before 2002.

†† 10–24 µg/dL BLL data were not complete.

TABLE 2. Reported numbers of adults* with blood lead levels ≥25 μg/dL, by exposure source, geographic division, and area — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012†

Division/Area	Exposure source			Total
	Occupational§	Nonoccupational	Unknown	
Total	**5,902**	**424**	**737**	**7,063**
New England				
Connecticut	28	22	3	53
Maine	7	11	—¶	18
Massachusetts	71	24	29	124
New Hampshire	7	—	9	16
Rhode Island	13	1	8	22
Vermont	7	1	—	8
Mid Atlantic				
New Jersey	148	16	14	178
New York	181	65	39	285
Pennsylvania	1,594	—	114	1,708
East North Central				
Illinois	185	30	103	318
Indiana	260	—	20	280
Michigan	93	32	7	132
Ohio	450	13	54	517
Wisconsin	86	11	3	100
West North Central				
Iowa	180	10	6	196
Kansas	200	—	34	234
Minnesota	96	6	21	123
Missouri	642	27	—	669
Nebraska	39	—	12	51
South Atlantic				
Florida	312	6	66	384
Maryland	50	7	6	63
North Carolina	88	21	3	112
South Carolina	58	—	8	66
East South Central				
Alabama	331	2	47	380
Tennessee	149	—	65	214
West South Central				
Louisiana	59	8	—	67
Texas	207	41	13	261
Mountain				
Colorado	28	7	9	44
Montana	2	—	—	2
New Mexico	5	1	1	7
Utah	5	1	20	26
Wyoming	12	—	—	12
Pacific				
Alaska	20	—	10	30
California	170	51	—	221
Hawaii	1	1	—	2
Oregon	42	4	7	53
Washington	76	5	6	87

* A 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.

† A total of 37 states reported data on exposure source in 2012. These data includes data from adult residents in the state and residents of other states reported by the State ABLES programs.

§ Includes 32 cases coded with both occupational and nonoccupational exposure source.

¶ No cases were reported.

TABLE 3. Reported number of cases and prevalence rate of adults* with blood lead levels ≥10 µg/dL, by state and age group — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012

State	16–24 yrs		25–39 yrs		40–64 yrs		≥65 yrs		Age not stated	Total
	No.	(Rate)	No.	(Rate)	No.	(Rate)	No.	(Rate)	No.	No.
Alabama										
All cases†	101	(41.8)	364	(59.7)	482	(44.6)	23	(25.3)	—§	970
State residents¶	101	(41.8)	363	(59.6)	482	(44.6)	23	(25.3)	—	969
Alaska										
All cases	19	(42.8)	86	(82.2)	108	(62.0)	6	(41.7)	—	219
State residents	12	(27.0)	62	(59.3)	62	(35.6)	3	(20.8)	—	139
Arizona										
All cases	26	(7.1)	68	(7.6)	114	(8.2)	23	(18.8)	7	238
State residents	26	(7.1)	68	(7.6)	114	(8.2)	23	(18.8)	7	238
California										
All cases	176	(8.7)	530	(9.5)	928	(11.4)	163	(20.7)	—	1,797
State residents	174	(8.6)	528	(9.4)	920	(11.3)	161	(20.5)	—	1,783
Colorado										
All cases	11	(3.5)	38	(4.5)	42	(3.4)	16	(13.5)	—	107
State residents	6	(1.9)	20	(2.4)	30	(2.4)	13	(11.0)	—	69
Connecticut										
All cases	17	(8.3)	55	(12.1)	170	(17.7)	39	(38.4)	—	281
State residents	17	(8.3)	53	(11.6)	167	(17.4)	39	(38.4)	—	276
Florida										
All cases	149	(16.6)	392	(15.1)	645	(14.0)	74	(14.8)	13	1,273
State residents	138	(15.4)	366	(14.1)	613	(13.3)	68	(13.6)	12	1,197
Georgia										
All cases	64	(12.7)	280	(20.0)	361	(15.8)	40	(23.9)	—	745
State residents	64	(12.7)	279	(19.9)	360	(15.7)	40	(23.9)	—	743
Hawaii										
All cases	1	(1.3)	8	(4.4)	18	(5.8)	1	(2.8)	—	28
State residents	1	(1.3)	7	(3.9)	18	(5.8)	1	(2.8)	—	27
Indiana										
All cases	74	(18.6)	361	(39.5)	603	(42.1)	43	(28.7)	—	1,081
State residents	74	(18.6)	361	(39.5)	603	(42.1)	43	(28.7)	—	1,081
Iowa										
All cases	67	(29.7)	202	(43.0)	521	(65.0)	26	(32.0)	—	816
State residents	67	(29.7)	202	(43.0)	521	(65.0)	26	(32.0)	—	816
Kansas										
All cases	76	(39.2)	354	(77.0)	619	(93.3)	34	(38.1)	—	1,083
State residents	76	(39.2)	354	(77.0)	619	(93.3)	34	(38.1)	—	1,083
Louisiana										
All cases	49	(19.8)	166	(25.9)	151	(16.2)	15	(14.2)	1	382
State residents	49	(19.8)	165	(25.7)	151	(16.2)	15	(14.2)	1	381
Maine										
All cases	7	(8.6)	28	(17.6)	79	(21.3)	19	(47.2)	—	133
State residents	7	(8.6)	28	(17.6)	79	(21.3)	19	(47.2)	—	133
Maryland										
All cases	24	(6.9)	116	(13.0)	115	(7.7)	17	(10.3)	1	273
State residents	23	(6.6)	108	(12.1)	105	(7.0)	17	(10.3)	—	253
Michigan										
All cases	36	(6.2)	208	(16.6)	342	(15.1)	45	(21.7)	—	631
State residents	36	(6.2)	208	(16.6)	342	(15.1)	44	(21.2)	—	630

See table footnotes on page 61.

TABLE 3. (*Continued*) Reported number of cases and prevalence rate of adults* with blood lead levels ≥10 µg/dL, by state and age group — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012

	16–24 yrs		25–39 yrs		40–64 yrs		≥65 yrs		Age not stated	Total
State	No.	(Rate)	No.	(Rate)	No.	(Rate)	No.	(Rate)	No.	No.
Minnesota										
All cases	40	(10.7)	174	(19.6)	253	(18.2)	26	(20.0)	—	493
State residents	40	(10.7)	174	(19.6)	253	(18.2)	26	(20.0)	—	493
Missouri										
All cases	222	(65.5)	1,043	(115.8)	1,650	(116.6)	58	(37.2)	—	2,973
State residents	222	(65.5)	1,043	(115.8)	1,650	(116.6)	58	(37.2)	—	2,973
Montana										
All cases	—	(—)	7	(5.0)	17	(7.3)	3	(7.2)	—	27
State residents	—	(—)	7	(5.0)	17	(7.3)	3	(7.2)	—	27
Nebraska										
All cases	15	(10.9)	61	(20.1)	84	(17.7)	8	(11.6)		168
State residents	15	(10.9)	61	(20.1)	84	(17.7)	8	(11.6)		168
New Hampshire										
All cases	7	(8.0)	56	(30.4)	81	(20.9)	11	(26.8)	—	155
State residents	7	(8.0)	56	(30.4)	81	(20.9)	11	(26.8)	—	155
New Jersey										
All cases	71	(14.7)	450	(38.2)	506	(23.0)	73	(26.8)	2	1,102
State residents	71	(14.7)	442	(37.5)	497	(22.6)	73	(26.8)	2	1,085
New Mexico										
All cases	4	(3.5)	12	(4.4)	31	(6.8)	3	(6.8)	—	50
State residents	4	(3.5)	12	(4.4)	31	(6.8)	3	(6.8)	—	50
New York										
All cases	176	(18.0)	782	(27.5)	1,091	(24.4)	100	(22.7)	—	2,149
State residents	161	(16.5)	686	(24.1)	980	(21.9)	97	(22.0)	—	1,924
North Carolina										
All cases	25	(4.7)	101	(7.4)	134	(6.1)	17	(7.7)	—	277
State residents	25	(4.7)	100	(7.3)	132	(6.0)	17	(7.7)	—	274
Ohio										
All cases	170	(22.5)	748	(48.1)	1,294	(47.8)	110	(34.7)	1	2,323
State residents	157	(20.8)	701	(45.0)	1,206	(44.5)	102	(32.2)	1	2,167
Oklahoma										
All cases	12	(5.4)	66	(11.7)	91	(11.1)	5	(4.1)	1	175
State residents	7	(3.2)	39	(6.9)	67	(8.2)	3	(2.4)	1	117
Oregon										
All cases	19	(8.6)	103	(18.8)	201	(22.1)	21	(22.2)	—	344
State residents	11	(5.0)	68	(12.4)	134	(14.7)	13	(13.7)	—	226
Pennsylvania										
All cases	429	(51.4)	1,019	(60.0)	1,608	(50.5)	81	(25.6)	1	3,138
State residents	429	(51.4)	1,019	(60.0)	1,607	(50.4)	81	(25.6)	1	3,137
Rhode Island										
All cases	6	(8.2)	25	(18.3)	62	(23.9)	11	(38.0)	—	104
State residents	6	(8.2)	25	(18.3)	62	(23.9)	11	(38.0)	—	104
South Carolina										
All cases	26	(10.9)	90	(14.3)	170	(16.8)	5	(5.0)	—	291
State residents	26	(10.9)	90	(14.3)	169	(16.7)	5	(5.0)	—	290
Tennessee										
All cases	77	(20.6)	346	(38.1)	531	(37.3)	29	(18.1)	2	985
State residents	63	(16.9)	298	(32.9)	451	(31.7)	24	(15.0)	2	838
Texas										
All cases	152	(10.3)	368	(8.9)	571	(10.1)	58	(10.8)	—	1,149
State residents	151	(10.2)	366	(8.9)	569	(10.1)	58	(10.8)	—	1,144
Utah										
All cases	9	(4.0)	59	(12.2)	79	(15.0)	17	(33.2)	—	164
State residents	2	(0.9)	13	(2.7)	32	(6.1)	9	(17.6)	—	56

See table footnotes on page 61.

TABLE 3. (*Continued*) Reported number of cases and prevalence rate of adults* with blood lead levels ≥10 μg/dL, by state and age group — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012

	16–24 yrs		25–39 yrs		40–64 yrs		≥65 yrs		Age not stated	Total
State	No.	(Rate)	No.	(Rate)	No.	(Rate)	No.	(Rate)	No.	No.
Vermont										
All cases	4	(10.4)	8	(8.8)	29	(15.3)	6	(28.3)	—	**47**
State residents	4	(10.4)	8	(8.8)	29	(15.3)	6	(28.3)	—	**47**
Washington										
All cases	30	(7.9)	99	(9.6)	143	(8.7)	11	(7.2)	—	**283**
State residents	18	(4.8)	62	(6.0)	93	(5.7)	5	(3.3)	—	**178**
Wisconsin										
All cases	37	(9.0)	184	(22.0)	452	(31.0)	33	(22.2)	2	**708**
State residents	37	(9.0)	184	(22.0)	452	(31.0)	33	(22.2)	2	**708**
Wyoming										
All cases	1	(2.6)	12	(13.5)	38	(26.7)	5	(26.3)	—	**56**
State residents	1	(2.6)	11	(12.4)	38	(26.7)	5	(26.3)	—	**55**

* A 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. To calculate rates, CDC estimated the number of employed adults (denominator) by age group and sex on the basis of data obtained from the Current Population Survey, U.S. Census Bureau.

† 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.

§ No cases were reported.

¶ Adults residing in the reporting state. States did not report this variable before 2002.

TABLE 4. Number of reported cases and prevalence of adults* with blood lead levels ≥10 µg/dL, by state and sex — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012

State	Male		Female		Sex not stated	Total
	No.	(Rate)	No.	(Rate)	No.	
Alabama						
All cases†	933	(87.4)	24	(2.5)	13	**970**
State residents§	932	(87.3)	24	(2.5)	13	**969**
Alaska						
All cases	207	(114.7)	12	(7.6)	—¶	**219**
State residents	130	(72.0)	9	(5.7)	—	**139**
Arizona						
All cases	226	(15.1)	12	(0.9)	—	**238**
State residents	226	(15.1)	12	(0.9)	—	**238**
California						
All cases	1,642	(18.1)	155	(2.1)	—	**1,797**
State residents	1,629	(18.0)	154	(2.1)	—	**1,783**
Colorado						
All cases	98	(7.2)	9	(0.8)	—	**107**
State residents	62	(4.6)	7	(0.6)	—	**69**
Connecticut						
All cases	265	(29.6)	14	(1.7)	2	**281**
State residents	260	(29.1)	14	(1.7)	2	**276**
Florida						
All cases	1,204	(26.9)	64	(1.6)	5	**1,273**
State residents	1,130	(25.2)	62	(1.5)	5	**1,197**
Georgia						
All cases	628	(27.2)	92	(4.5)	25	**745**
State residents	627	(27.2)	91	(4.4)	25	**743**
Hawaii						
All cases	22	(6.9)	6	(2.1)	—	**28**
State residents	22	(6.9)	5	(1.8)	—	**27**
Indiana						
All cases	1,020	(66.2)	57	(4.2)	4	**1,081**
State residents	1,020	(66.2)	57	(4.2)	4	**1,081**
Iowa						
All cases	724	(88.0)	92	(12.1)	—	**816**
State residents	724	(88.0)	92	(12.1)	—	**816**
Kansas						
All cases	941	(127.0)	141	(21.1)	1	**1,083**
State residents	941	(127.0)	141	(21.1)	1	**1,083**
Louisiana						
All cases	371	(36.0)	11	(1.2)	—	**382**
State residents	370	(35.9)	11	(1.2)	—	**381**
Maine						
All cases	106	(31.5)	27	(8.6)	—	**133**
State residents	106	(31.5)	27	(8.6)	—	**133**
Maryland						
All cases	260	(17.8)	12	(0.8)	1	**273**
State residents	240	(16.4)	12	(0.8)	1	**253**
Michigan						
All cases	591	(26.0)	40	(2.0)	—	**631**
State residents	590	(26.0)	40	(2.0)	—	**630**
Minnesota						
All cases	459	(31.2)	34	(2.6)	—	**493**
State residents	459	(31.2)	34	(2.6)	—	**493**

See table footnotes on page 63.

TABLE 4. (*Continued*) Number of reported cases and prevalence of adults* with blood lead levels ≥10 µg/dL, by state and sex — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012

State	Male		Female		Sex not stated	Total
	No.	(Rate)	No.	(Rate)	No.	
Missouri						
All cases	2,625	(178.9)	348	(25.8)	—	**2,973**
State residents	2,625	(178.9)	348	(25.8)	—	**2,973**
Montana						
All cases	21	(8.5)	5	(2.2)	1	**27**
State residents	21	(8.5)	5	(2.2)	1	**27**
Nebraska						
All cases	159	(30.7)	5	(1.1)	4	**168**
State residents	159	(30.7)	5	(1.1)	4	**168**
New Hampshire						
All cases	151	(41.4)	4	(1.2)	—	**155**
State residents	151	(41.4)	4	(1.2)	—	**155**
New Jersey						
All cases	1,059	(48.4)	40	(2.1)	3	**1,102**
State residents	1,044	(47.7)	38	(1.9)	3	**1,085**
New Mexico						
All cases	45	(9.7)	5	(1.2)	—	**50**
State residents	45	(9.7)	5	(1.2)	—	**50**
New York						
All cases	1,826	(40.1)	323	(7.7)	—	**2,149**
State residents	1,605	(35.2)	319	(7.6)	—	**1,924**
North Carolina						
All cases	253	(11.1)	23	(1.1)	1	**277**
State residents	250	(10.9)	23	(1.1)	1	**274**
Ohio						
All cases	2,160	(76.9)	156	(6.1)	7	**2,323**
State residents	2,011	(71.6)	152	(6.0)	4	**2,167**
Oklahoma						
All cases	159	(16.8)	16	(2.0)	—	**175**
State residents	104	(11.0)	13	(1.7)	—	**117**
Oregon						
All cases	322	(34.6)	18	(2.1)	4	**344**
State residents	211	(22.7)	14	(1.7)	1	**226**
Pennsylvania						
All cases	3,015	(94.2)	118	(4.1)	5	**3,138**
State residents	3,014	(94.2)	118	(4.1)	5	**3,137**
Rhode Island						
All cases	95	(37.5)	9	(3.6)	—	**104**
State residents	95	(37.5)	9	(3.6)	—	**104**
South Carolina						
All cases	262	(25.7)	25	(2.6)	4	**291**
State residents	262	(25.7)	24	(2.5)	4	**290**
Tennessee						
All cases	832	(54.3)	82	(6.1)	71	**985**
State residents	709	(46.3)	71	(5.3)	58	**838**
Texas						
All cases	1,079	(16.6)	69	(1.3)	1	**1,149**
State residents	1,075	(16.6)	68	(1.3)	1	**1,144**
Utah						
All cases	153	(21.1)	10	(1.8)	1	**164**
State residents	52	(7.2)	4	(0.7)	—	**56**

See table footnotes on page 63.

TABLE 4. (*Continued*) Number of reported cases and prevalence of adults* with blood lead levels ≥10 µg/dL, by state and sex — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2012

State	Male		Female		Sex not stated	Total
	No.	(Rate)	No.	(Rate)	No.	
Vermont						
All cases	43	(24.7)	4	(2.4)	—	**47**
State residents	43	(24.7)	4	(2.4)	—	**47**
Washington						
All cases	273	(16.0)	9	(0.6)	1	**283**
State residents	172	(10.1)	6	(0.4)	—	**178**
Wisconsin						
All cases	640	(43.3)	66	(4.8)	2	**708**
State residents	640	(43.3)	66	(4.8)	2	**708**
Wyoming						
All cases	46	(28.6)	10	(7.7)	—	**56**
State residents	45	(28.0)	10	(7.7)	—	**55**

* A 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. To calculate rates, CDC estimated the number of employed adults (denominator) by age group and sex on the basis of data obtained from the Current Population Survey, U.S. Census Bureau.

† 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. States did not report this variable before 2002.

¶ No cases were reported.

TABLE 5. Number and national prevalence rates per 100,000 employed adults* of adults with blood lead levels ≥10 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2010–2012†

Characteristic	2010	2011	2012
Prevalence rate			
All cases§	26.6	23.9	22.5
State residents¶	25.0	22.9	21.6
No. of cases			
All cases	30,738	28,456	27,218
State residents	28,928	27,279	26,034
Employed population			
Total (in 1,000s)	**115,768**	**119,128**	**120,763**

* A 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. Rates were calculated on the basis of data on the number of employed adults (denominator), which were obtained from the Local Area Unemployment Statistics (LAUS) program, Bureau of labor Statistics, U.S. Department of Labor.

† A total of 37 states participated in 2010; 38 states participated in 2011 and 2012.

§ All cases reported by a state. These include cases among adults residing in the reporting state plus cases identified by the reporting state but who reside in another state.

¶ Adults residing in the reporting state.

TABLE 6. National prevalence rates per 100,000 employed adults* of adults with blood lead levels ≥25 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 1994–2012

Characteristic	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
No. of states participating	17	18	20	24	24	25	25	23	35	36
Prevalence rate										
All cases†	14.0	14.9	15.0	14.8	12.1	11.6	11.9	10.9	9.2	8.7
State residents§	¶	¶	¶	¶	¶	¶	¶	¶	8.5	8.2
No. of cases										
All cases	9,225	10,260	11,607	12,613	10,454	10,309	10,718	9,517	10,690	10,404
State residents	**	**	**	**	**	**	**	**	9,922	9,809
Employed population (in 1,000s)										
Total in reporting states	**65,706**	**68,787**	**77,444**	**85,390**	**86,759**	**88,943**	**90,111**	**87,477**	**116,325**	**119,302**

Characteristic	2004	2005	2006	2007	2008	2009	2010	2011	2012
No. of states participating	37	37	38	38††	40††	40	39	41	41
Prevalence rate									
All cases†	7.9	7.5	7.7	7.8	7.4	6.3	7.0	6.6	5.7
State residents§	7.6	7.3	7.5	7.6	7.1	6.1	6.7	6.4	5.6
No. of cases									
All cases	9,530	9,235	9,880	10,190	9,709	7,992	8,738	8,567	7,529
State residents	9,169	8,934	9,613	9,882	9,212	7,725	8,369	8,366	7,332
Employed population (in 1,000s)									
Total in reporting states	**121,203**	**123,191**	**128,378**	**130,943**	**131,510**	**126,689**	**124,880**	**130,156**	**131,879**

* A 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. Rates were calculated on the basis of data on the number of employed adults (denominator), which were obtained from the Local Area Unemployment Statistics (LAUS) program, Bureau of labor Statistics, U.S. Department of Labor.

† All cases reported by a state. These include cases among adults residing in the reporting state plus cases identified by the reporting state but who reside in another state.

§ Adults residing in the reporting state. States did not report this variable before 2002.

¶ Rates were not calculated because data for state residents were not available.

** Data for state residents were not available.

†† Montana reported zero cases of state residents with elevated BLLs in 2007 and Kentucky did not report state-resident data in 2008. National state-resident rates were calculated by excluding the employed population in these states for these years.

TABLE 7. Number of reported cases and prevalence rate per 100,000 of employed adults* of persons with blood lead levels ≥10 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2010–2012

State	2010		2011		2012	
	No.	(Rate)	No.	(Rate)	No.	(Rate)
Alabama						
All cases†	832	(42.1)	998	(49.8)	970	(48.3)
State residents§	831	(42.0)	992	(49.5)	969	(48.2)
Alaska						
All cases	267	(80.2)	264	(78.3)	219	(64.4)
State residents	70	(21.0)	83	(24.6)	139	(40.9)
Arizona						
All cases	167	(6.0)	217	(7.9)	238	(8.6)
State residents	167	(6.0)	217	(7.9)	238	(8.6)
California						
All cases	1,746	(10.9)	1,819	(11.2)	1,797	(10.8)
State residents	1,702	(10.6)	1,778	(10.9)	1,783	(10.8)
Colorado						
All cases	—¶	(—)	64	(2.6)	107	(4.2)
State residents	—	(—)	31	(1.2)	69	(2.7)
Connecticut						
All cases	446	(25.7)	330	(19.0)	281	(16.2)
State residents	431	(24.8)	317	(18.3)	276	(16.0)
Florida						
All cases	886	(10.9)	1,082	(13.0)	1,273	(14.9)
State residents	864	(10.6)	1,082	(13.0)	1,197	(14.0)
Georgia						
All cases	530	(12.5)	635	(14.8)	745	(17.2)
State residents	508	(12.0)	630	(14.7)	743	(17.1)
Hawaii						
All cases	15	(2.5)	28	(4.6)	28	(4.6)
State residents	15	(2.5)	28	(4.6)	27	(4.4)
Indiana						
All cases	1,387	(48.7)	1,386	(48.0)	1,081	(37.1)
State residents	1,387	(48.7)	1,386	(48.0)	1,081	(37.1)
Iowa						
All cases	735	(46.9)	829	(52.9)	816	(51.8)
State residents	735	(46.9)	829	(52.9)	816	(51.8)
Kansas						
All cases	1,155	(82.7)	1,143	(81.7)	1,083	(77.3)
State residents	1,155	(82.7)	1,143	(81.7)	1,083	(77.3)
Kentucky						
All cases	1,805	(97.2)	—	(—)	—	(—)
State residents	1,745	(94.0)	—	(—)	—	(—)
Louisiana						
All cases	287	(15.0)	309	(16.1)	382	(19.7)
State residents	287	(15.0)	309	(16.1)	381	(19.6)

See table footnotes on page 66.

TABLE 7. (*Continued*) Number of reported cases and prevalence rate per 100,000 of employed adults* of persons with blood lead levels ≥10 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2010–2012

State	2010		2011		2012	
	No.	(Rate)	No.	(Rate)	No.	(Rate)
Maine						
All cases	120	(18.6)	85	(13.1)	133	(20.3)
State residents	120	(18.6)	85	(13.1)	133	(20.3)
Maryland						
All cases	209	(7.4)	273	(9.5)	273	(9.4)
State residents	170	(6.0)	265	(9.2)	253	(8.7)
Michigan						
All cases	598	(14.4)	625	(14.9)	631	(14.9)
State residents	590	(14.2)	615	(14.7)	630	(14.9)
Minnesota						
All cases	572	(20.8)	428	(15.4)	493	(17.6)
State residents	572	(20.8)	428	(15.4)	493	(17.6)
Missouri						
All cases	2,951	(107.3)	2,988	(108.2)	2,973	(106.7)
State residents	2,951	(107.3)	2,988	(108.2)	2,973	(106.7)
Montana						
All cases	88	(19.0)	34	(7.3)	27	(5.7)
State residents	26	(5.6)	34	(7.3)	27	(5.7)
Nebraska						
All cases	163	(17.3)	141	(14.7)	168	(17.2)
State residents	163	(17.3)	141	(14.7)	168	(17.2)
New Hampshire						
All cases	225	(32.4)	214	(30.7)	155	(22.1)
State residents	225	(32.4)	214	(30.7)	155	(22.1)
New Jersey						
All cases	1,187	(28.9)	1,261	(30.7)	1,102	(26.6)
State residents	1,119	(27.2)	1,146	(27.9)	1,085	(26.2)
New Mexico						
All cases	63	(7.4)	61	(7.1)	50	(5.8)
State residents	57	(6.7)	61	(7.1)	50	(5.8)
New York						
All cases	2,552	(29.1)	2,376	(27.1)	2,149	(24.4)
State residents	2,222	(25.4)	2,136	(24.4)	1,924	(21.9)
North Carolina						
All cases	484	(11.7)	395	(9.4)	277	(6.5)
State residents	482	(11.7)	391	(9.4)	274	(6.4)
Ohio						
All cases	3,002	(57.1)	2,049	(38.8)	2,323	(43.7)
State residents	2,880	(54.8)	1,988	(37.6)	2,167	(40.8)
Oklahoma						
All cases	—	(—)	65	(3.9)	175	(10.3)
State residents	—	(—)	54	(3.2)	117	(6.9)

See table footnotes on page 66.

TABLE 7. (*Continued*) Number of reported cases and prevalence rate per 100,000 of employed adults* of persons with blood lead levels ≥10 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2010–2012

	2010		2011		2012	
State	No.	(Rate)	No.	(Rate)	No.	(Rate)
Oregon						
All cases	355	(20.2)	312	(17.6)	344	(19.4)
State residents	340	(19.4)	295	(16.6)	226	(12.7)
Pennsylvania						
All cases	3,904	(66.7)	4,042	(68.7)	3,138	(52.7)
State residents	3,895	(66.6)	4,030	(68.5)	3,137	(52.7)
Rhode Island						
All cases	159	(31.5)	134	(26.8)	104	(20.7)
State residents	159	(31.5)	134	(26.8)	104	(20.7)
South Carolina						
All cases	240	(12.5)	216	(11.1)	291	(14.6)
State residents	102	(5.3)	216	(11.1)	290	(14.6)
Tennessee						
All cases	967	(34.8)	1,189	(42.0)	985	(34.6)
State residents	632	(22.7)	942	(33.3)	838	(29.4)
Texas						
All cases	1,203	(10.7)	1,156	(10.1)	1,149	(9.8)
State residents	1,157	(10.3)	1,149	(10.0)	1,144	(9.7)
Utah						
All cases	170	(13.6)	129	(10.2)	164	(12.6)
State residents	75	(6.0)	56	(4.4)	56	(4.3)
Vermont						
All cases	57	(16.9)	63	(18.6)	47	(13.9)
State residents	57	(16.9)	63	(18.6)	47	(13.9)
Washington						
All cases	332	(10.5)	278	(8.8)	283	(8.8)
State residents	159	(5.0)	187	(5.9)	178	(5.6)
Wisconsin						
All cases	831	(29.4)	782	(27.6)	708	(24.8)
State residents	830	(29.4)	781	(27.5)	708	(24.8)
Wyoming						
All cases	48	(17.1)	56	(19.7)	56	(19.4)
State residents	48	(17.1)	55	(19.3)	55	(19.0)

* A 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. Rates were calculated on the basis of data on the number of employed adults (denominator), which were obtained from the Local Area Unemployment Statistics (LAUS) program, Bureau of labor Statistics, U.S. Department of Labor.

† All cases reported by a state. These include cases among adults residing in the reporting state plus cases identified by the reporting state but who reside in another state.

§ Adults residing in the reporting state. States did not report this variable before 2002.

¶ Data unavailable.

TABLE 8. Reported prevalence rate per 100,000 employed adults of adults* with blood lead levels ≥25 μg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2002–2012

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alabama											
All cases†	23.8	27.3	30.5	29.6	27.3	24.2	20.6	15.4	18.2	21.5	18.9
State residents§	23.8	27.3	30.5	29.6	27.3	24.2	20.6	15.4	18.2	21.2	18.9
Alaska											
All cases	—¶	13.5	8.3	13.1	12.3	9.4	6.6	4.5	9.6	10.1	8.8
State residents	—	1.0	4.1	6.9	3.4	3.0	2.1	3.0	4.5	5.6	6.8
Arizona											
All cases	0.8	1.4	2.0	0.7	1.0	0.9	1.1	1.1	0.7	1.4	1.6
State residents	0.8	1.4	2.0	0.7	1.0	0.9	1.0	1.0	0.7	1.4	1.6
California											
All cases	4.2	3.4	2.8	2.6	2.2	2.1	2.2	2.0	1.5	1.4	1.3
State residents	3.8	3.0	2.6	2.5	2.1	2.0	2.2	2.0	1.5	1.4	1.3
Colorado											
All cases	—	—	—	—	—	—	—	—	—	1.0	1.7
State residents	—	—	—	—	—	—	—	—	—	0.8	1.5
Connecticut											
All cases	4.1	3.7	2.4	3.8	3.5	4.2	4.1	3.5	4.3	4.3	3.1
State residents	3.9	3.6	2.0	3.6	3.4	4.2	4.1	3.5	4.0	3.9	3.1
Florida											
All cases	4.4	3.9	3.3	2.7	2.3	1.5	2.3	2.5	3.1	3.2	4.5
State residents	4.4	3.9	3.3	2.7	2.3	1.5	2.3	2.5	3.1	3.2	4.3
Georgia											
All cases	4.1	6.5	3.3	8.6	6.2	4.3	4.2	3.7	3.9	4.5	4.7
State residents	4.1	6.5	3.3	8.6	6.2	4.3	4.2	3.7	3.7	4.5	4.7
Hawaii											
All cases	1.2	—	0.8	0.5	1.6	—	0.5	0.5	0.2	1.1	0.3
State residents	1.2	—	0.8	0.5	1.6	—	0.5	0.5	0.2	1.1	0.3
Illinois											
All cases	10.1	7.7	5.9	6.2	6.5	6.2	5.4	4.8	4.6	4.5	5.3
State residents	10.1	7.7	5.9	6.1	6.5	6.2	5.3	4.6	4.6	4.4	5.2
Indiana											
All cases	—	12.7	18.6	19.9	16.8	22.1	12.1	15.5	16.2	14.6	9.6
State residents	—	12.6	18.5	19.9	16.8	22.1	12.1	15.5	16.2	14.6	9.6
Iowa											
All cases	29.0	22.3	16.0	16.7	15.9	20.2	16.9	11.8	11.1	15.3	12.4
State residents	29.0	22.3	16.0	16.7	15.9	20.2	16.9	11.8	11.1	15.3	12.4
Kansas											
All cases	46.6	41.4	33.6	34.0	24.9	27.3	22.5	22.6	22.8	20.9	16.7
State residents	43.9	39.8	33.6	34.0	24.9	27.3	22.5	22.6	22.8	20.9	16.7
Kentucky											
All cases	20.2	14.8	10.3	9.8	13.9	15.3	10.1	6.9	15.2	8.0	7.3
State residents	20.2	14.8	7.8	8.4	12.8	13.3	NA	6.4	14.0	7.7	6.4
Louisiana											
All cases	—	—	—	—	—	8.8	9.5	7.1	2.4	3.1	3.5
State residents	—	—	—	—	—	8.8	9.3	7.0	2.4	3.1	3.5

See table footnotes on page 69.

TABLE 8. (*Continued*) Reported prevalence rate per 100,000 employed adults of adults* with blood lead levels ≥25 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2002–2012

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Maine											
All cases	7.1	6.9	6.6	4.0	4.8	3.0	3.8	2.2	4.2	2.2	2.7
State residents	7.1	6.9	4.7	4.0	4.8	3.0	3.8	2.2	4.2	2.2	2.7
Maryland											
All cases	4.8	4.6	3.1	2.7	2.3	3.9	3.9	3.7	3.7	2.0	2.2
State residents	4.7	3.4	2.2	1.5	1.8	3.3	3.1	2.8	2.9	1.9	2.1
Massachusetts											
All cases	9.1	7.6	7.8	6.3	7.1	5.6	5.3	5.3	5.4	6.1	3.8
State residents	7.3	6.9	7.2	5.8	6.1	5.0	4.9	4.7	4.5	5.5	3.6
Michigan											
All cases	4.1	3.7	3.4	2.8	2.3	2.8	2.8	2.5	2.5	2.8	3.1
State residents	4.1	3.5	3.2	2.7	2.3	2.8	2.8	2.4	2.4	2.7	3.1
Minnesota											
All cases	6.0	6.7	5.2	4.8	4.8	5.6	4.5	3.5	4.1	3.2	4.4
State residents	6.0	6.7	5.2	4.7	4.8	5.6	4.5	3.5	4.1	3.2	4.4
Missouri											
All cases	32.9	33.1	26.8	30.9	32.1	37.2	35.3	26.5	30.7	28.2	24.0
State residents	15.1	24.7	26.3	29.0	30.6	36.0	34.4	26.4	30.7	28.2	24.0
Montana											
All cases	0.9	1.1	1.8	0.9	1.5	1.0	2.1	3.0	2.6	0.6	0.4
State residents	0.9	1.1	1.8	0.9	0.2	**	1.2	2.4	1.1	0.6	0.4
Nebraska											
All cases	4.8	6.3	5.5	4.5	3.3	5.4	5.0	5.1	5.0	4.1	5.2
State residents	4.8	6.3	5.5	4.5	3.3	5.4	5.0	5.1	5.0	4.1	5.2
New Hampshire											
All cases	9.1	8.4	7.6	7.6	6.4	5.5	7.0	4.2	4.3	3.9	2.3
State residents	8.4	8.4	7.6	7.6	6.4	5.5	7.0	4.2	4.3	3.9	2.3
New Jersey											
All cases	10.4	10.2	9.5	9.5	7.8	3.3	4.7	4.9	5.8	5.1	4.3
State residents	10.4	8.7	7.8	8.7	7.3	3.1	4.5	4.7	5.5	4.5	4.3
New Mexico											
All cases	1.8	1.1	1.3	0.6	0.8	0.8	1.1	1.0	0.8	1.9	0.8
State residents	1.8	1.1	1.3	0.6	0.8	0.8	1.0	1.0	0.7	1.9	0.8
New York											
All cases	9.2	7.3	7.8	6.2	5.6	3.6	3.8	3.2	4.6	3.8	3.2
State residents	8.4	6.8	7.2	5.6	5.3	3.3	3.5	2.8	3.9	3.5	3.0
North Carolina											
All cases	5.5	5.6	4.5	3.2	3.7	4.8	3.9	3.5	5.6	3.5	2.6
State residents	5.5	5.6	4.4	3.1	3.7	4.7	3.8	3.4	5.6	3.5	2.6
Ohio											
All cases	16.5	13.0	12.4	13.2	10.9	10.9	10.8	10.2	13.1	10.4	9.7
State residents	16.5	13.0	12.3	13.1	10.9	10.9	10.7	10.2	13.0	10.2	9.3
Oklahoma											
All cases	3.9	6.1	5.1	3.0	4.0	1.9	2.3	2.0	—	2.5	4.7
State residents	3.9	5.3	4.6	3.0	3.6	1.3	1.6	2.0	—	2.1	3.8

See table footnotes on page 69.

TABLE 8. (*Continued*) Reported prevalence rate per 100,000 employed adults of adults* with blood lead levels ≥25 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2002–2012

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Oregon											
All cases	4.1	4.5	4.8	3.5	2.7	3.4	3.9	2.7	2.2	3.0	3.0
State residents	4.1	4.2	4.1	3.3	2.7	3.4	3.9	2.0	1.9	2.7	2.1
Pennsylvania											
All cases	26.0	31.3	30.2	20.9	32.2	34.3	37.6	32.2	35.7	39.3	28.7
State residents	25.8	31.3	30.2	20.9	32.2	34.0	37.3	32.0	35.6	39.2	28.7
Rhode Island											
All cases	20.4	8.3	7.0	7.7	7.2	6.1	4.9	5.4	5.9	6.4	4.4
State residents	20.4	7.7	7.0	7.7	7.2	6.1	4.9	5.4	5.9	6.4	4.4
South Carolina											
All cases	6.7	4.2	6.1	12.1	6.9	5.6	3.7	1.6	3.7	2.1	3.3
State residents	6.7	4.2	5.4	12.1	6.9	5.6	3.6	0.6	1.5	2.1	3.3
Tennessee											
All cases	—	—	—	—	19.8	21.2	19.5	9.7	9.4	9.4	7.5
State residents	—	—	—	—	19.5	19.1	17.3	7.7	6.3	8.2	6.9
Texas											
All cases	3.4	2.4	2.0	2.3	2.4	2.3	2.9	2.9	2.5	2.5	2.2
State residents	3.4	2.4	2.0	2.3	2.4	2.3	2.5	2.7	2.5	2.4	2.2
Utah											
All cases	4.0	5.2	3.0	4.3	3.0	2.6	2.6	2.6	1.9	1.6	2.0
State residents	4.0	5.1	2.8	4.0	2.5	2.4	2.3	2.4	1.2	0.7	0.6
Vermont											
All cases	—	—	—	—	—	—	5.6	4.2	3.3	5.0	2.4
State residents	—	—	—	—	—	—	5.6	4.2	3.3	5.0	2.4
Washington											
All cases	2.8	3.6	2.3	2.0	2.5	2.3	1.7	2.6	2.7	2.3	2.7
State residents	2.7	2.7	2.1	1.6	2.0	1.8	1.5	2.1	2.1	2.0	2.4
Wisconsin											
All cases	9.0	7.4	7.0	6.0	5.2	7.9	6.5	5.6	4.2	4.2	3.5
State residents	9.0	7.4	7.0	6.0	5.2	7.9	6.5	5.6	4.2	4.1	3.5
Wyoming											
All cases	4.3	5.0	10.7	15.7	10.1	9.6	6.6	5.0	2.1	4.6	4.2
State residents	4.3	5.0	10.7	15.7	10.1	9.2	6.3	5.0	2.1	4.6	4.2

Abbreviation: NA = not available; program did not report state resident data this year.

* A 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.

† All cases reported by a state. These include cases among adults residing in the reporting state plus cases identified by the reporting state but who reside in another state.

§ Adults residing in the reporting state. States did not report this variable before 2002.

¶ Data were unavailable because the state did not participate in the program for this year.

** Reported zero cases of state residents with elevated BLLs for this year.

TABLE 9. Number of reported cases of adults* with blood lead levels ≥25 μg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2002–2012

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alabama											
All cases†	474	544	612	608	572	509	423	298	360	431	380
State residents§	474	544	612	608	572	509	423	298	359	425	380
Alaska											
All cases	—¶	42	26	42	40	31	22	15	32	34	30
State residents	—	3	13	22	11	10	7	10	15	19	23
Arizona											
All cases	21	35	54	19	27	27	31	30	18	39	43
State residents	21	35	54	18	27	27	29	29	18	39	43
California											
All cases	686	554	462	436	368	349	372	324	238	231	221
State residents	622	481	421	413	346	337	369	317	234	227	218
Colorado											
All cases	—	—	—	—	—	—	—	—	—	26	44
State residents	—	—	—	—	—	—	—	—	—	21	37
Connecticut											
All cases	69	62	41	66	61	73	72	61	74	74	53
State residents	66	61	34	61	59	73	72	60	70	67	53
Florida											
All cases	335	301	267	227	194	135	198	200	253	262	384
State residents	335	301	267	227	194	134	198	200	251	262	363
Georgia											
All cases	170	271	138	375	279	199	191	158	165	192	205
State residents	170	271	138	375	279	199	191	157	158	192	203
Hawaii											
All cases	7	—	5	3	10	—	3	3	1	7	2
State residents	7	—	5	3	10	—	3	3	1	7	2
Illinois											
All cases	600	457	354	373	405	392	339	282	274	265	318
State residents	600	457	352	369	402	389	333	273	273	262	312
Indiana											
All cases	—	380	556	604	518	682	371	444	462	423	280
State residents	—	378	555	604	516	681	371	444	462	423	280
Iowa											
All cases	455	343	245	260	253	324	272	185	173	240	196
State residents	455	343	245	260	253	324	272	185	173	240	196
Kansas											
All cases	630	565	464	473	349	385	318	316	318	293	234
State residents	593	543	464	473	349	385	318	316	318	293	234
Kentucky											
All cases	372	274	191	183	265	294	193	127	283	151	138
State residents	372	274	144	158	244	255	NA	118	260	144	122
Louisiana											
All cases	—	—	—	—	—	170	187	136	46	59	67
State residents	—	—	—	—	—	170	183	135	46	59	67

See table footnotes on page 72.

TABLE 9. (*Continued*) Number of reported cases of adults* with blood lead levels ≥25 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2002–2012

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Maine											
All cases	46	45	43	26	32	20	25	14	27	14	18
State residents	46	45	31	26	32	20	25	14	27	14	18
Maryland											
All cases	132	126	85	75	66	113	114	103	106	56	63
State residents	128	93	60	42	51	96	89	80	82	54	61
Massachusetts											
All cases	296	245	249	203	232	183	174	168	173	196	124
State residents	237	222	230	186	198	165	160	151	142	176	117
Michigan											
All cases	195	173	157	133	108	132	128	103	102	116	132
State residents	194	162	149	129	107	132	127	102	101	115	132
Minnesota											
All cases	164	185	143	131	134	156	125	96	113	88	123
State residents	164	185	143	130	134	156	125	96	113	88	123
Missouri											
All cases	932	931	755	881	928	1,078	1,014	736	845	780	669
State residents	427	695	740	826	885	1,042	987	734	845	780	669
Montana											
All cases	4	5	8	4	7	5	10	14	12	3	2
State residents	4	5	8	4	1	**	6	11	5	3	2
Nebraska											
All cases	44	59	52	42	31	51	48	48	47	39	51
State residents	44	59	52	42	31	51	48	48	47	39	51
New Hampshire											
All cases	62	57	52	53	45	39	50	29	30	27	16
State residents	57	57	52	53	45	39	50	29	30	27	16
New Jersey											
All cases	430	417	392	401	331	141	199	202	239	210	178
State residents	430	358	325	367	309	131	193	196	227	186	176
New Mexico											
All cases	15	9	11	5	7	7	10	9	7	16	7
State residents	15	9	11	5	7	7	9	9	6	16	7
New York											
All cases	801	639	683	552	511	330	350	285	402	331	285
State residents	728	593	631	503	480	299	318	246	342	308	260
North Carolina											
All cases	217	221	183	132	157	205	168	142	230	147	112
State residents	217	221	176	129	157	200	161	140	230	147	112
Ohio											
All cases	910	716	680	730	608	611	601	544	689	548	517
State residents	910	715	676	723	608	611	594	544	684	539	495

See table footnotes on page 72.

TABLE 9. (*Continued*) Number of reported cases of adults* with blood lead levels ≥25 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 2002–2012

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Oklahoma											
All cases	62	97	82	49	66	31	39	33	—	41	80
State residents	62	85	74	48	59	22	27	33	—	35	65
Oregon											
All cases	70	77	82	60	49	62	71	47	39	54	53
State residents	69	71	70	58	48	62	71	35	34	48	38
Pennsylvania											
All cases	1,526	1,816	1,770	1,244	1,937	2,074	2,296	1,897	2,087	2,312	1,708
State residents	1,512	1,816	1,770	1,244	1,937	2,058	2,276	1,886	2,084	2,309	1,708
Rhode Island											
All cases	107	44	37	41	39	33	26	27	30	32	22
State residents	107	41	37	41	39	33	26	27	30	32	22
South Carolina											
All cases	123	78	115	233	136	112	73	31	72	41	66
State residents	123	78	102	233	136	112	71	11	29	41	66
Tennessee											
All cases	—	—	—	—	564	614	555	264	260	267	214
State residents	—	—	—	—	557	554	493	210	176	232	195
Texas											
All cases	344	246	202	241	254	255	321	318	287	282	261
State residents	344	246	202	241	254	251	281	295	279	279	260
Utah											
All cases	44	59	35	53	38	35	35	33	24	20	26
State residents	44	58	33	49	32	32	31	30	15	9	8
Vermont											
All cases	—	—	—	—	—	—	19	14	11	17	8
State residents	—	—	—	—	—	—	19	14	11	17	8
Washington											
All cases	79	105	69	62	78	73	57	83	84	72	87
State residents	77	78	63	49	63	57	48	66	67	62	78
Wisconsin											
All cases	257	213	202	173	153	233	190	159	119	118	100
State residents	257	213	202	173	153	233	190	159	119	117	100
Wyoming											
All cases	11	13	28	42	28	27	19	14	6	13	12
State residents	11	13	28	42	28	26	18	14	6	13	12

Abbreviation: NA = not available; program did not report state resident data this year.

* A 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.

† All cases reported by a state. These include cases among adults residing in the reporting state plus cases identified by the reporting state but who reside in another state.

§ Adults residing in the reporting state. States did not report this variable before 2002.

¶ Data were unavailable because the state did not participate in the program in this year.

** Reported zero cases of state residents with elevated BLLs for this year.

TABLE 10. Reported number of cases and prevalence rate per 100,000 employed adults of adults* with blood lead levels ≥25 µg/dL — State Adult Blood Lead Epidemiology and Surveillance programs, United States, 1994–2001

	1994		1995		1996		1997		1998		1999		2000		2001	
State	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Alabama	502	(26.3)	—†	(—)	511	(25.6)	567	(27.9)	549	(26.7)	490	(23.7)	634	(30.6)	578	(28.4)
Arizona	40	(2.0)	148	(7.1)	56	(2.6)	79	(3.6)	91	(4.0)	48	(2.0)	58	(2.4)	35	(1.4)
California	1,347	(9.7)	997	(7.1)	1,010	(7.1)	1,044	(7.1)	900	(5.9)	911	(5.9)	1,001	(6.2)	872	(5.4)
Connecticut	354	(21.2)	262	(15.8)	229	(13.8)	207	(12.4)	118	(7.0)	124	(7.3)	99	(5.8)	77	(4.5)
Iowa	—	—	533	(34.9)	522	(33.7)	421	(27.1)	309	(19.9)	401	(25.7)	268	(17.2)	432	(27.5)
Maryland	196	(7.7)	178	(6.9)	153	(5.9)	189	(7.1)	162	(6.1)	292	(10.9)	229	(8.5)	205	(7.5)
Massachusetts	755	(25.3)	641	(21.2)	582	(18.9)	507	(16.1)	470	(14.7)	429	(13.2)	368	(11.2)	297	(9.1)
Michigan	—	(—)	—	(—)	—	(—)	135	(2.8)	298	(6.2)	272	(5.6)	238	(4.8)	208	(4.3)
Minnesota	—	(—)	467	(18.5)	255	(9.9)	258	(9.9)	264	(9.9)	272	(10.1)	190	(7.0)	244	(8.8)
Nebraska	—	(—)	—	(—)	—	(—)	—	(—)	—	(—)	143	(15.6)	94	(10.2)	—	(—)
New Hampshire	—	(—)	—	(—)	—	(—)	187	(29.4)	213	(32.7)	174	(26.1)	212	(31.3)	142	(20.9)
New Jersey	744	(19.6)	611	(15.9)	592	(15.1)	567	(14.1)	511	(12.6)	534	(13.1)	572	(13.9)	543	(13.2)
New York	955	(11.8)	850	(10.5)	1,115	(13.6)	1,045	(12.4)	903	(10.6)	948	(11.0)	955	(10.9)	834	(9.6)
North Carolina	224	(6.4)	342	(9.6)	269	(7.3)	362	(9.5)	379	(9.9)	426	(10.9)	280	(7.1)	345	(8.7)
Ohio	—	(—)	—	(—)	1,367	(25.4)	1,440	(26.4)	1,146	(20.9)	1,090	(19.7)	1,039	(18.7)	1,572	(28.2)
Oklahoma	52	(3.5)	76	(5.1)	94	(6.2)	88	(5.7)	67	(4.3)	46	(2.9)	66	(4.1)	49	(3.0)
Oregon	269	(17.4)	199	(12.6)	204	(12.6)	187	(11.3)	129	(7.7)	170	(10.0)	180	(10.5)	89	(5.2)
Pennsylvania	2,005	(36.3)	2,897	(52.2)	2,862	(50.6)	3,348	(58.0)	2,394	(41.4)	2,031	(35.0)	2,826	(48.5)	2,113	(36.0)
Rhode Island	—	(—)	—	(—)	—	(—)	104	(20.6)	78	(15.3)	67	(12.9)	178	(34.2)	95	(18.3)
South Carolina	367	(21.2)	595	(33.9)	188	(10.5)	189	(10.4)	195	(10.6)	32	(1.7)	60	(3.2)	—	(—)
Texas	387	(4.4)	189	(2.1)	738	(8.0)	687	(7.3)	556	(5.8)	510	(5.2)	554	(5.6)	307	(3.1)
Utah	83	(8.8)	102	(10.4)	57	(5.7)	98	(9.5)	75	(7.1)	41	(3.8)	34	(3.1)	45	(4.1)
Washington	232	(9.0)	241	(9.1)	203	(7.5)	277	(9.8)	152	(5.3)	148	(5.1)	160	(5.5)	120	(4.2)
Wisconsin	713	(26.3)	932	(33.6)	600	(21.3)	528	(18.5)	428	(14.9)	671	(23.3)	376	(13.0)	294	(10.1)
Wyoming	—	(—)	—	(—)	—	(—)	99	(40.6)	67	(27.0)	39	(15.5)	47	(18.3)	21	(8.1)

* A 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. Rates are forAll reported cases by the state. These include adult residents in the reporting state plus residents of other states. State resident data were only available from 2002 onwards.

† Data were unavailable because the state did not participate in the ABLES program in this year.

TABLE 11. Total number (in 1000s) of state-resident employed adults* (denominators), by state and year — United States, 2002–2012†

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alabama	1,995	1,990	2,007	2,052	2,098	2,104	2,054	1,937	1,978	2,004	2,010
Alaska	—†	311	315	321	326	330	333	331	333	337	340
Arizona	2,513	2,573	2,650	2,725	2,837	2,898	2,913	2,822	2,782	2,761	2,774
California	16,181	16,200	16,355	16,592	16,821	16,961	16,894	16,155	16,068	16,250	16,590
Colorado	—	—	—	—	—	—	—	—	—	2,493	2,531
Connecticut	1,701	1,697	1,704	1,719	1,746	1,761	1,769	1,741	1,737	1,737	1,731
Florida	7,663	7,786	7,998	8,305	8,584	8,839	8,637	8,140	8,131	8,311	8,547
Georgia	4,135	4,174	4,249	4,375	4,500	4,588	4,541	4,295	4,235	4,280	4,342
Hawaii	584	—	598	610	618	—	617	593	604	614	612
Illinois	5,969	5,917	5,969	6,033	6,225	6,322	6,248	5,938	5,925	5,937	5,982
Indiana	—	2,998	2,998	3,032	3,080	3,082	3,057	2,873	2,851	2,890	2,912
Iowa	1,568	1,537	1,535	1,558	1,595	1,604	1,609	1,571	1,566	1,569	1,577
Kansas	1,351	1,365	1,381	1,390	1,404	1,411	1,416	1,400	1,397	1,399	1,401
Kentucky	1,838	1,848	1,855	1,876	1,904	1,924	1,907	1,850	1,857	1,879	1,900
Louisiana	—	—	—	—	—	1,934	1,965	1,916	1,919	1,917	1,944
Maine	651	650	654	659	666	666	665	643	645	651	656
Maryland	2,733	2,741	2,762	2,825	2,893	2,885	2,893	2,814	2,833	2,871	2,910
Massachusetts	3,243	3,209	3,204	3,220	3,256	3,277	3,278	3,188	3,187	3,212	3,235
Michigan	4,725	4,676	4,687	4,717	4,723	4,678	4,551	4,204	4,151	4,192	4,244
Minnesota	2,750	2,751	2,752	2,757	2,775	2,768	2,772	2,714	2,744	2,776	2,795
Missouri	2,830	2,814	2,816	2,850	2,889	2,895	2,870	2,776	2,751	2,762	2,787
Montana	445	450	456	463	476	486	487	466	463	467	477
Nebraska	921	932	938	935	943	953	962	939	944	960	979
New Hampshire	680	679	688	697	709	714	714	696	694	698	702
New Jersey	4,117	4,108	4,144	4,208	4,258	4,265	4,262	4,136	4,109	4,112	4,137
New Mexico	823	836	850	866	887	904	905	870	856	854	860
New York	8,721	8,704	8,816	8,947	9,062	9,098	9,111	8,834	8,767	8,755	8,806
North Carolina	3,931	3,974	4,031	4,124	4,261	4,284	4,280	4,108	4,138	4,183	4,271
Ohio	5,503	5,499	5,503	5,537	5,603	5,611	5,550	5,312	5,260	5,287	5,317
Oklahoma	1,602	1,599	1,606	1,629	1,650	1,664	1,676	1,647	—	1,671	1,698
Oregon	1,704	1,700	1,714	1,741	1,792	1,822	1,827	1,751	1,757	1,777	1,777
Pennsylvania	5,869	5,796	5,860	5,958	6,021	6,054	6,105	5,898	5,851	5,885	5,954
Rhode Island	526	533	526	533	544	544	528	504	505	499	501
South Carolina	1,826	1,854	1,888	1,922	1,971	2,010	1,998	1,912	1,925	1,955	1,989
Tennessee	—	—	—	—	2,853	2,902	2,854	2,715	2,779	2,828	2,846
Texas	10,115	10,229	10,385	10,552	10,758	10,914	11,076	11,074	11,281	11,506	11,762
Utah	1,114	1,139	1,179	1,230	1,285	1,329	1,330	1,273	1,253	1,262	1,303
Vermont	—	—	—	—	—	—	342	335	337	338	338
Washington	2,877	2,913	3,000	3,076	3,155	3,233	3,285	3,194	3,167	3,154	3,203
Wisconsin	2,861	2,863	2,868	2,890	2,932	2,949	2,941	2,845	2,823	2,838	2,850
Wyoming	258	259	262	268	277	282	287	281	281	285	289

* Persons aged ≥16 years in the civilian noninstitutionalizedpopulation who, during the reference week (the week including the 12th day of the month), either 1) did any work as paid employees, worked in their own business or profession or on their own farm, or worked 15 hours or more as unpaid workers in an enterprise operated by a member of their family, or 2) were not working but who had jobs from which they were temporarily absent because of vacation, illness, bad weather, childcare problems, maternity or paternity leave, labor-management dispute job training, or other family or personal reasons, whether or not they were paid for the time off or were seeking other jobs. Each employed person is counted only once, even if he or she holds more than one job. Source: US Department of Labor, Bureau of Labor Statistics. Local Area Unemployment Statistics (LAUS) program. Washington, DC: Department of Labor, Bureau of Labor Statistics; 2014. Available at http://www.bls.gov/lau/staadata.txt.

† No denominator data were provided because the state did not participate in the ABLES program in these years.

TABLE 12. Total number (in 1,000s) of state-resident employed adults* (denominators) by state and year — United States, 1994–2001

State	1994	1995	1996	1997	1998	1999	2000	2001
Alabama	1,910	—†	1,993	2,035	2,059	2,070	2,073	2,033
Arizona	1,977	2,096	2,146	2,197	2,279	2,355	2,406	2,453
California	13,954	14,062	14,304	14,781	15,204	15,567	16,034	16,217
Connecticut	1,670	1,658	1,660	1,675	1,685	1,695	1,698	1,698
Iowa	—	1,528	1,551	1,556	1,556	1,561	1,561	1,570
Maryland	2,545	2,573	2,616	2,646	2,661	2,688	2,703	2,719
Massachusetts	2,989	3,029	3,083	3,159	3,209	3,246	3,277	3,275
Michigan	—	—	—	4,749	4,810	4,897	4,967	4,865
Minnesota	—	2,529	2,566	2,606	2,657	2,687	2,733	2,764
Nebraska	—	—	—	—	—	916	926	—
New Hampshire	—	—	—	635	651	666	677	681
New Jersey	3,790	3,846	3,926	4,031	4,047	4,093	4,129	4,112
New York	8,080	8,126	8,229	8,417	8,547	8,657	8,764	8,730
North Carolina	3,511	3,583	3,704	3,810	3,845	3,921	3,959	3,949
Ohio	—	—	5,378	5,448	5,489	5,534	5,571	5,570
Oklahoma	1,469	1,491	1,515	1,543	1,569	1,591	1,608	1,615
Oregon	1,547	1,583	1,619	1,653	1,678	1,697	1,721	1,709
Pennsylvania	5,530	5,554	5,662	5,775	5,788	5,810	5,832	5,870
Rhode Island	—	—	—	504	510	519	521	520
South Carolina	1,729	1,755	1,786	1,820	1,849	1,877	1,896	—
Texas	8,779	8,986	9,176	9,395	9,601	9,766	9,913	10,004
Utah	945	979	1,004	1,034	1,061	1,080	1,096	1,103
Washington	2,567	2,636	2,712	2,822	2,887	2,918	2,899	2,861
Wisconsin	2,713	2,774	2,816	2,856	2,870	2,879	2,891	2,899
Wyoming	—	—	—	244	248	252	257	260

* Persons aged ≥16 years in the civilian noninstitutionalized population who were employed during the reference week. Source: US Department of Labor, Bureau of Labor Statistics. 2003 Local Area Unemployment Statistics (LAUS) program. Washington, DC: Department of Labor, Bureau of Labor Statistics; 2004. Available at http://www.bls.gov/lau/staadata.txt.

† No denominator data were provided because the state did not participate in the ABLES program in these years.

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APPENDIX B

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

Table 1. **Health– based management recommendations for lead-exposed adults**

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Blood lead level (µg/dL)	Short-term risks (lead exposure <1 year)	Long-term risks (lead exposure ≥ 1 year)	Management
<5	None documented	None documented	None Indicated
5-9	Possible spontaneous abortion Possible postnatal developmental delay	Possible spontaneous abortion Possible postnatal developmental delay Possible hypertension and kidney dysfunction	Discuss health risks Reduce lead exposure for women who are or may become pregnant
10-19	Possible spontaneous abortion Possible postnatal developmental delay Reduced birth weight	Possible spontaneous abortion Possible postnatal developmental delay Hypertension and kidney dysfunction Reduced birth weight Possible subclinical neurocognitive deficits	Discuss health risks Reduce lead exposure for women who are or may become pregnant Decrease lead exposure Increase biological monitoring Consider removal from lead exposure to avoid long-term risks if exposure control over an extended period does not decrease BLL<10 µg/dL or if medical condition present that increases risk with continued exposure
20-29	Possible spontaneous abortion Possible postnatal developmental delay Reduced birth weight	Possible spontaneous abortion Possible postnatal developmental delay Hypertension and kidney dysfunction Reduced birth weight Possible subclinical neurocognitive deficits	Remove from lead exposure if repeat BLL measured in 4 weeks remains ≥20 µg/dL
30-39	Spontaneous abortion Possible postnatal developmental delay Reduced birth weight	Spontaneous abortion Possible postnatal developmental delay Hypertension and kidney dysfunction Reduced birth weight Possible subclinical neurocognitive deficits Possible nonspecific symptoms*	Remove from lead exposure
40-79	Spontaneous abortion Possible postnatal developmental delay Reduced birth weight Nonspecific symptoms* Neurocognitive deficits Sperm abnormalities	Spontaneous abortion Possible postnatal developmental delay Hypertension Kidney dysfunction/neuropathy Subclinical peripheral neuropathy Reduced birth weight Neurocognitive deficits Nonspecific symptoms* Sperm abnormalities Anemia Colic Possible gout	Remove from lead exposure Refer for prompt medical evaluation Consider chelation therapy for BLL > 50 µg/dL with significant symptoms or signs of lead toxicity
≥90	Spontaneous abortion Possible postnatal developmental delay Reduced birth weight Nonspecific symptoms* Neurocognitive deficits Sperm abnormalities Encephalopathy Anemia Colic	Spontaneous abortion Possible postnatal developmental delay Hypertension Neuropathy Peripheral neuropathy Reduced birth weight Neurocognitive deficits Nonspecific symptoms* Sperm abnormalities Anemia Colic Gout	Remove from lead exposure Refer for immediate/urgent medical evaluation Probable chelation therapy

*Medical conditions that may increase the risk of continued exposure include chronic renal dysfunctions (serum creatinine > 1.5 mg/dL for women or protein urial, hypertension , neurologic disorders and cognitive dysfunction. Non specific symptoms may include headache, fatigue, sleep disturbance, anorexia, constipation, orthralgia, myalgia, and decreased libido.