

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

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Preface

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

Background

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

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

or below the national prevalence rate) (Figure 1). Trends of national prevalence rates of BLLs ≥ 10 $\mu\text{g}/\text{dL}$ and BLLs ≥ 25 $\mu\text{g}/\text{dL}$ from 1994 to 2013 are provided (Figure 2).

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

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

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

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

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

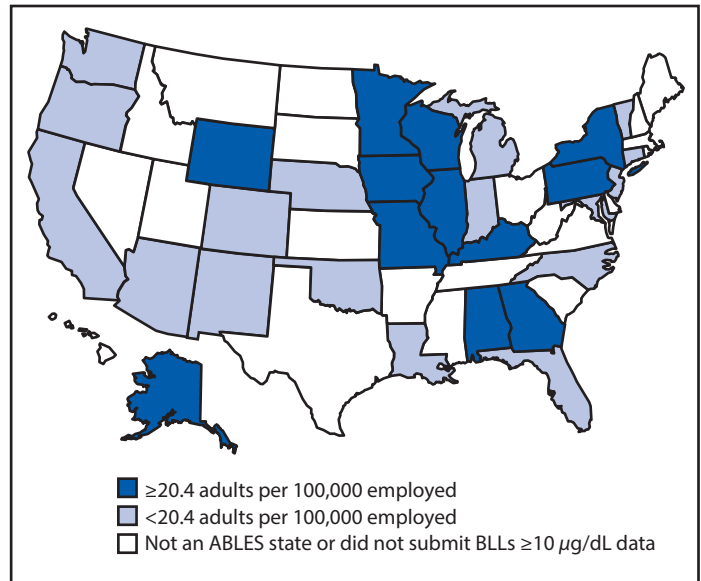
Data Sources

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

Interpreting Data

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

FIGURE 1. Prevalence rate* of adults with blood lead levels (BLLs) $\geq 10 \mu\text{g}/\text{dL}$, by state — State Adult Blood Lead Epidemiology and Surveillance (ABLES) programs, United States, 2013†



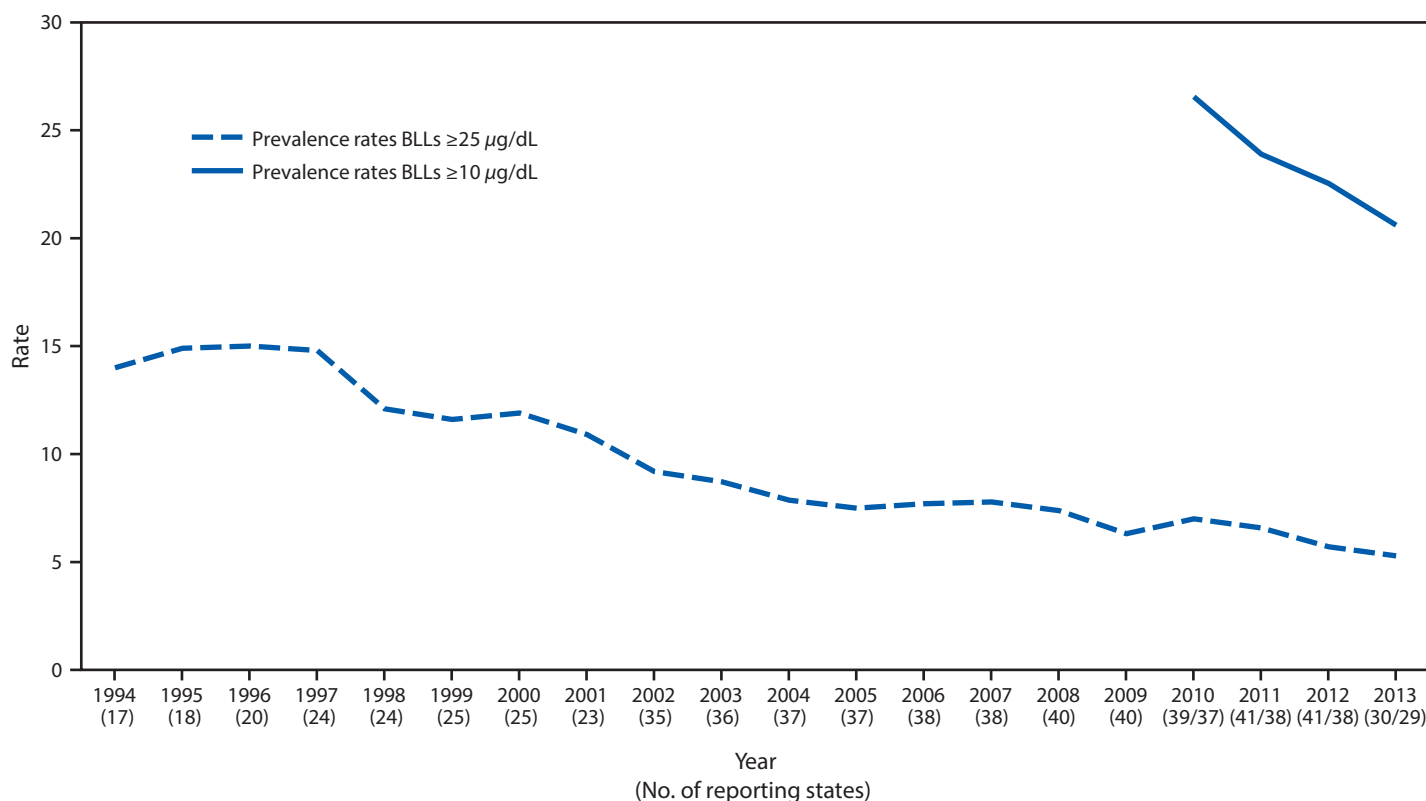
* Rate per 100,000 employed adults aged ≥ 16 years. State-resident prevalence rate might be lower for some states. Data from the Adult Blood Epidemiology and Surveillance (ABLES) Program, National Institute for Occupational Safety and Health (NIOSH/CDC). Denominators for 2013 extracted from 2015 U.S.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

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

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

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

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



Abbreviation: BLL = blood lead level.

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

[†] Since 2009, the case definition for an elevated blood lead level is a BLL ≥ 10 $\mu\text{g}/\text{dL}$. For historical comparisons, prevalence rates at the previous case definition (BLL ≥ 25 $\mu\text{g}/\text{dL}$) are provided.

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

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

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

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

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

Methods for Identifying Elevated BLLs Among Employed Adults

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

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

Publication Criteria

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

Highlights

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

100,000 employed in 1994 (among 17 states) to 5.2 in 2013 (among 30 states).

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

TABLE 1. Reported numbers of cases and prevalence rates of adults* with blood lead levels ≥ 10 $\mu\text{g}/\text{dL}$ and blood lead levels ≥ 25 $\mu\text{g}/\text{dL}$, by geographic division and area — state Adult Blood Lead Epidemiology and Surveillance programs, United States, 2013[†]

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

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

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

[§] The numbers and rates of adults with BLLs ≥ 25 $\mu\text{g}/\text{dL}$ are subsets of the numbers and rates of adults with BLLs ≥ 10 $\mu\text{g}/\text{dL}$.

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

^{**} Adults residing in the reporting state.

^{††} 10–15 $\mu\text{g}/\text{dL}$ BLL data were not available.

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

TABLE 2. Reported numbers of adults* with blood lead levels $\geq 25 \mu\text{g}/\text{dL}$, by exposure source and area — state Adult Blood Lead Epidemiology and Surveillance programs, United States, 2013[†]

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

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

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

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

[¶] No cases were reported.

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