

# Elevated blood lead levels in adults—Missouri, 2013

Kerton R. Victory PhD<sup>1</sup>  | Carol R. Braun<sup>2</sup> | Marie A. de Perio MD<sup>3</sup> |  
Geoffrey M. Calvert MD<sup>3</sup> | Walter Alarcon MD<sup>3</sup>

<sup>1</sup> National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Atlanta, Georgia

<sup>2</sup> Missouri Department of Health & Senior Services, Jefferson City, Missouri

<sup>3</sup> National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio

## Correspondence

Kerton R. Victory, PhD, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, 1600 Clifton Road, Mailstop: E20, Atlanta, Georgia 30329.  
Email: kvictory@cdc.gov

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**Background:** Over 90% of adults with elevated blood lead levels (BLLs) in the United States are exposed occupationally. Missouri historically has been among the states with the highest prevalence rates of elevated BLLs. We characterized cases of elevated BLLs among Missouri adults to target preventive interventions.

**Methods:** We reviewed 2013 data on Missouri residents  $\geq 16$  years from the Missouri Adult Blood Lead Epidemiology and Surveillance system and analyzed characteristics of those with elevated BLLs. We used the contemporaneous CDC definition of elevated BLL as  $\geq 10 \mu\text{g}/\text{dL}$ .

**Results:** Of the 15 123 residents with a BLL in 2013 (median:  $1.5 \mu\text{g}/\text{dL}$ , range: 0–151  $\mu\text{g}/\text{dL}$ ), 3145 (21%) had BLLs  $\geq 10 \mu\text{g}/\text{dL}$ . Occupational exposures accounted for the majority of residents ( $n = 3099$ , 98%) with elevated BLLs, mostly in battery manufacturing ( $n = 1373$ , 44%) and lead mining ( $n = 821$ , 26%) industries.

**Conclusions:** Our findings highlight the need for focused interventions targeting battery manufacturing and lead mining, the high-risk industries, to further reduce overexposures to lead.

## KEYWORDS

adult blood lead epidemiology and surveillance, blood lead level, medical surveillance, NIOSH, occupational lead exposure, OSHA

## 1 | BACKGROUND

In certain industries, workers continue to have elevated blood lead levels (BLLs) despite the overall decline in BLLs.<sup>1–4</sup> In the United States, when the exposure source is known, over 95% of adults with elevated BLLs are exposed occupationally. The state of Missouri has historically been among the states with the highest prevalence rates of elevated BLLs among adults.<sup>2,5</sup> The Missouri Adult Blood Lead Epidemiology and Surveillance program (MO-ABLES) was established in 2001 to identify workers who have been overexposed to lead.<sup>6</sup> The MO-ABLES program currently contributes to objective OSH-7 in Healthy

People 2020 which has a goal to reduce the proportion of persons who have BLLs  $\geq 10 \mu\text{g}/\text{dL}$  from work exposures to 20.2 persons per 100 000 employed adults.<sup>7</sup> However, the new CDC reference value was lowered to 5  $\mu\text{g}/\text{dL}$  in 2015 because more recent research has found decreased renal function, and increased risk of hypertension and essential tremor at lower BLLs.<sup>8</sup>

Over the last decade, ABLES data showed that workers in battery manufacturing, construction, and mining industries had the greatest proportions of elevated BLLs.<sup>2,5,9</sup> In 2013, among 2313 occupational cases with BLLs  $\geq 25 \mu\text{g}/\text{dL}$  available from 22 states participating in ABLES, the majority were employed in four main industry sectors: manufacturing ( $n = 1227$  [53.1%]), construction ( $n = 468$  [20.2%]), services ( $n = 194$  [8.4%]), and mining ( $n = 182$  [7.9%]).<sup>9</sup> The MO-ABLES program, like other state ABLES programs, monitors laboratory-reported BLLs in adults aged  $\geq 16$  years who have been tested through either a workplace lead monitoring program or on the basis of clinical

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suspicion of lead overexposure. OSHA's National Emphasis Program to reduce occupational exposures to lead states that "referrals received from States' Departments of Health, Labor or Industry alleging elevated employee blood lead levels (defined as blood lead levels at or above 25 µg/dL) and/or involving take-home exposures, shall be considered high-gravity, serious and must be handled by inspection."<sup>10</sup> In 2014, the MO-ABLES program signed a memorandum of understanding (MoU) with the U.S. Occupational Safety and Health Administration (OSHA) region seven office to refer workplaces to OSHA who had employees with blood lead levels  $\geq 25$  µg/dL. As of November 2018, this MoU has led to 27 referrals to OSHA representing 663 workers with lead overexposures.

Although the MoU was implemented, lead overexposures among workers in high-risk industries of battery manufacturing and lead mining remain a problem in the state of Missouri and more intervention efforts are needed to further protect workers who are overexposed to lead. This paper describes the characteristics of Missouri adults in 2013 with BLLs  $\geq 10$  µg/dL and provides recommendations to target interventions to prevent lead overexposures. Specific aims of this investigation were to: (i) characterize the proportion of Missouri adults with elevated BLLs; (ii) estimate the prevalence of elevated BLLs among Missouri adults; and (iii) provide recommendations to target populations to reduce overexposures.

## 2 | METHODS

Blood lead level data collected by the MO-ABLES program in 2013 were included in this report. MO-ABLES collects blood lead data from adults, including all blood lead levels and demographic information, such as age, race, and sex. The primary sources of BLL reports are public and private laboratories; secondary sources are physicians. Laboratory-reported BLLs for all adults are received by the program through file transfer protocol, email, fax, or regular mail. For adults with BLLs  $\geq 10$  µg/dL the program actively pursues information on the industry where the adult is employed. Additional information on cases, such as exposure source and any missing demographic data, was obtained via investigation by MO-ABLES program staff. A case was defined as a Missouri resident aged 16 or older with a BLL  $\geq 10$  µg/dL, which was CDC's reference blood lead level for adults from 2009 to 2015.<sup>5</sup> Note that the current definition for an elevated BLL in adults is  $\geq 5$  µg/dL. Occupational exposure was defined as lead exposure occurring at the workplace. This determination was made by MO-ABLES program staff. For these analyses, when an adult had more than one BLL record in 2013, only the highest BLL was included.

### 2.1 | Statistical analysis

We performed statistical analyses using SAS® 9.3 (Research Triangle Institute, Research Triangle Park, NC). We analyzed blood lead data by sex, age, race, and industry sector. We recoded the North American Industry Classification System (NAICS, 2002) industry codes into the NIOSH National Occupational Research Agenda (NORA) sector groups. We obtained resident employed population estimates in Missouri from the Bureau of Labor Statistics. We calculated prevalence

using the following formula: the total number of Missouri residents with an elevated BLL divided by the number of employed Missouri residents aged  $\geq 16$  years multiplied by 100 000.

## 3 | RESULTS

For 2013, the prevalence rate of elevated BLLs among Missouri residents was calculated at 111.5 per 100 000 employed adults, which was approximately five times the U.S. national prevalence rate of 20.4.<sup>9</sup> A total of 15 123 Missouri residents aged  $\geq 16$  years had a reported blood lead test in 2013 with a median BLL of 1.5 µg/dL (range: 0-151 µg/dL). Of these, 3145 (21%) had BLLs  $\geq 10$  µg/dL (Table 1). Among those with BLLs  $\geq 10$  µg/dL, 2456 (78%) had a BLL of 10-24 µg/dL, and 689 (22%) had a BLL  $\geq 25$  µg/dL. Most adults with a BLL  $\geq 10$  µg/dL were male (88%), aged 35 years or older (68%), and white (83%) (Table 1). There were 41 (1%) adults with elevated BLLs who had non-occupational sources of lead exposure. The most common non-occupational sources were from shooting firearms ( $n = 26$ ) and gunshot wounds with retained bullet fragments ( $n = 5$ ).

Occupational exposures accounted for 3099 (99%) of elevated BLLs (Table 2). Among these 3099 occupational cases, Missouri was the state of employment for 2834 workers, other states for 251 workers, and state of employment was unknown for 14 cases. The majority of adults with elevated BLLs in Missouri were employed in Jefferson, Iron, Johnson, or Greene counties (55%) (Figure 1). Among the 3099 occupational cases, the majority of cases were from manufacturing (64%,  $N = 1987$ ), including lead battery manufacturing (44%,  $n = 1373$ ) and smelting or refining of nonferrous metals, (16%,  $n = 487$ ); followed by mining industries (27%,  $N = 821$ ), including lead and zinc ore mining (26%,  $n = 819$ ) (Table 2). In these two NORA sectors, 2213 (79%) had an elevated BLL between 10 and 24 µg/dL and 595 (21%) had an elevated BLL  $\geq 25$  µg/dL.

**TABLE 1** Distribution of adults with BLLs 10-24 µg/dL and BLLs  $\geq 25$  µg/dL by sex, age, and race

	BLL 10-24 µg/dL	BLL $\geq 25$ µg/dL	%
Total	2456	689	100
Sex			
Male	2141	640	88.0
Female	315	49	12.0
Age (years)			
<35	772	230	32.0
$\geq 35$	1684	459	68.0
Race			
White	2048	568	83.0
Black	95	23	4.0
Asian	11	3	0.5
American Indian	8	1	0.3
Pacific Islander	3	1	0.1
Unknown	290	94	12.0

**TABLE 2** Workers with elevated blood lead levels by NIOSH National Occupational Research Agenda (NORA) sectors, Missouri 2013

NORA industry sector [NAICS 2002 industry code]	BLL 10-24 µg/dL	BLL ≥25 µg/dL	Total
Construction	102	68	170
New single-family housing construction (except operative builders) [236115]	32	31	63
Plumbing, heating, and air-conditioning contractors [238220]	24	25	49
Painting and wall covering contractors [238320]	14	3	17
Other in construction	32	9	41
Manufacturing	1550	437	1987
Storage battery manufacturing [335911]	757	251	1008
Primary battery manufacturing [335912]	359	6	365
Secondary smelting, refining, and alloying of nonferrous metal (except copper and aluminum) [331492]	234	115	349
Nonferrous metal (except copper and aluminum) rolling, drawing, and extruding [331491]	70	24	94
Metal coating, engraving (except jewelry and silverware), and allied services to manufacturers [332812]	41	21	62
Small arms ammunition manufacturing [332992]	27	6	33
Nonferrous (except aluminum) die-casting foundries [331522]	23	4	27
Other nonferrous foundries (except die-casting) [331528]	16	1	17
Other in manufacturing	23	9	32
Mining (except oil & gas extraction)	663	158	821
Lead ore and zinc ore mining [212231]	661	158	819
Crushed and broken limestone mining and quarrying [212312]	2		2
Other NORA sector	34	11	45
Other/missing	34	11	45
Services (except public safety)	68	8	76
All other amusement and recreation industries [713990]	18	3	21
Other services to buildings and dwellings [561790]	20		20
Other in services	30	5	35
Total	2417	682	3099

The highest reported BLL for 2013 was 151 µg/dL from an occupational exposure. The worker was a 35-year-old male who was employed in the construction industry. The exposure occurred while using a cutting torch on a construction project repairing a bridge. The worker returned to work after a BLL of <40 µg/dL was reported.

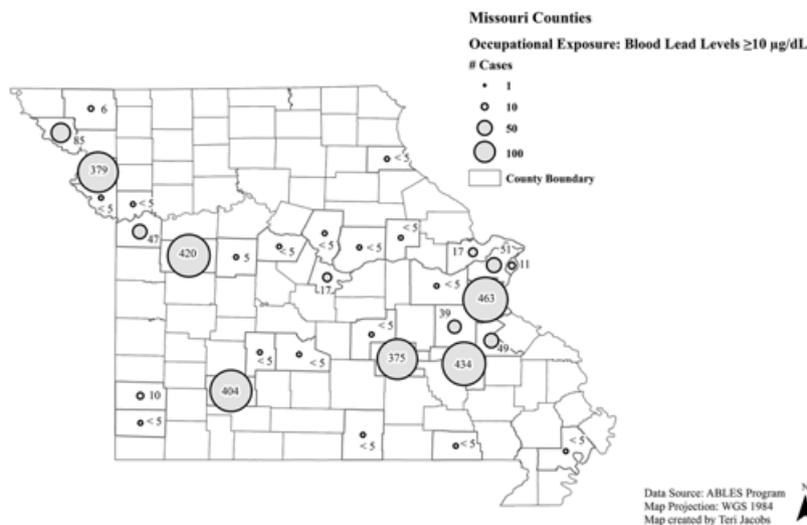
## 4 | DISCUSSION

This paper examines the distribution of adults with elevated BLLs in a state where occupational exposures to lead remain a public health challenge. Occupational lead overexposures in Missouri continue to be a health hazard especially in battery manufacturing and in lead mining industries. These findings are consistent with reports describing manufacturing, construction, and mining as the industry sectors with the greatest proportions of adults with elevated BLLs.<sup>2,5,11</sup> Furthermore, workers employed in Jefferson, Iron, Johnson, or Greene counties, which are areas where battery manufacturing and lead mining are concentrated in Missouri, accounted for the majority of lead overexposures. Historically, these are known industries for having lead overexposed workers in the state of Missouri.<sup>9</sup> Although the definition

of an elevated blood level was lowered to ≥10 µg/dL in 2009 and then to ≥5 µg/dL in 2015, many workers in these industries still have BLLs above the old reference value of 25 µg/dL, suggesting that more intervention efforts are needed to protect workers in these industries.

The highest reported BLL in 2013 was 151 µg/dL from an occupational exposure in the construction industry. Previous studies have shown that construction is another industry with high risk of lead exposure and also one in which there is underreporting of elevated BLLs.<sup>5,12,13</sup> One reason for underreporting is that employers in the construction industry may be less likely to conduct medical surveillance and identify cases of elevated BLLs.<sup>14</sup>

The findings in this study are subject to some limitations. OSHA standards require employers to conduct medical surveillance of lead exposed employees. In industries where lead is well known, such as battery manufacturing and lead mining this appears to be taking place in Missouri. However, in industries where lead exposure may not be prominent, a substantial proportion of these workers may not receive blood lead testing. A study conducted in the state of Washington in 1998 found that only 17% of employers of lead exposed workers routinely tested their employees for lead overexposure.<sup>15</sup> Furthermore, workers in industries that are less likely



**FIGURE 1** Residents with elevated blood lead levels ( $\geq 10$   $\mu\text{g}/\text{dL}$ ) by county of employment, Missouri 2013. The majority of elevated BLLs cases were employed in Jefferson ( $n = 463$ ), Iron ( $n = 434$ ), Johnson ( $n = 420$ ), and Greene counties ( $n = 404$ )

to offer blood lead testing, such as construction or house remodeling, may not be tested until they become symptomatic and seek medical care.<sup>12,13</sup> Therefore, the findings of this study likely represent an underestimate of the actual extent of elevated BLLs in Missouri. In addition, there is limited data on industry and occupation for those adults with non-elevated BLLs in MO-ABLES database.

In addition to occupational exposures, nonoccupational exposures to lead are also of concern. While there were only 41 (1%) adults with elevated BLLs that were non-occupational, the majority of cases were related to shooting firearms, which is an evolving recreational activity contributing to both occupational (other amusement and recreation industries) and nonoccupational lead exposures in the state of Missouri. Previous studies have documented elevated levels of exposure to lead from indoor firing ranges.<sup>16,17</sup> These studies concluded that firing range employees, customers and family members of firing range customers and employees can be exposed to hazardous amounts of lead.

The MO-ABLES 2013 data are the most recent available after federal funding for State ABLES programs was discontinued in September 2013. MO-ABLES continues to collaborate with NIOSH since occupational lead overexposures has remained a health hazard over the past 5 years. In 2014, after the data for this report were collected, MO-ABLES collaborated with NIOSH to establish an agreement with the OSHA Regional Office to share information to protect workers from lead overexposures. As of November 2018, this has led MO-ABLES to refer a total of 27 companies representing 663 Missouri workers with BLLs  $\geq 25$   $\mu\text{g}/\text{dL}$  to OSHA. Additionally, a NIOSH Health Hazard evaluation was conducted in 2014-2015 at a large battery manufacturing facility in Missouri, hazards were identified, and the company took measures to alleviate hazards to workers' health.<sup>18</sup> Educational materials on both occupational and nonoccupational lead exposure risks were also created by the MO-ABLES program.

Intervention strategies to further reduce lead exposures in Missouri include collaboration with private employers, workers, and other government agencies to create educational materials focusing on adult

lead poisoning prevention. The materials will include information on the possible means of exposure to lead, both occupational and non-occupational, and will be made available to employers and the public.

In conclusion, the fact that many Missouri adults have elevated BLLs is of significant concern and underscores the need for increased efforts to prevent lead exposure at workplaces and in nonoccupational settings. The MO-ABLES program identified areas where prevention efforts could be further improved. Blood lead surveillance programs need to be strengthened across all industries, especially in construction where there might be lack of blood lead testing and thus underreporting of lead-exposed workers. In addition, more focused efforts by employers, employees, health providers, and government agencies are needed to reduce lead overexposure for high-risk industries such as battery manufacturing and lead and zinc ore mining. These efforts should include (i) improving engineering controls, such as local exhaust ventilation and enclosures; (ii) adherence by lead-exposed workers to safe work practices, such as properly using personal protective equipment, washing hands before eating, and showering and changing clothes before going home; (iii) and increasing efforts to educate employers, workers, and the medical community on existing CDC guidelines and OSHA standards and programs.<sup>19,20</sup> Implementation of these efforts across all industries can ultimately reduce the prevalence of lead overexposure in Missouri and contribute to the Healthy People 2020 goal to reduce the national prevalence of lead exposures in the United States.

## AUTHORS' CONTRIBUTIONS

Kerton Victory, Carol Braun, Marie de Perio, Geoffrey Calvert, and Walter Alarcon contributed to study conception and design; Kerton Victory, Carol Braun, and Walter Alarcon contributed to acquisition of data and analysis; Kerton Victory, Carol Braun, Geoffrey Calvert, and Walter Alarcon interpreted the data; Kerton Victory, Marie de Perio, and Walter Alarcon drafted the report; and all the authors contributed to revision of the report and approved the version submitted.

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Since all data came from the publically available NIOSH Adult Blood Lead Epidemiology and Surveillance (ABLES) program, and Missouri Department of Health & Senior Services ABLES program, no ethics review or approval occurred.

## DISCLOSURE (AUTHORS)

The authors declare no conflicts of interest.

## DISCLOSURE BY AJIM EDITOR OF RECORD

John D. Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

## DISCLAIMER

The findings and conclusions in this report presented here are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

## ORCID

Kerton R. Victory  <http://orcid.org/0000-0001-5503-0889>

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