North Carolina Adult Blood Lead Epidemiology Surveillance (ABLES) Program

Summary of Findings for 2017

North Carolina Division of Public Health
Occupational and Environmental Epidemiology

More information about the ABLES can be found at:
https://epi.publichealth.nc.gov/oee/programs/ables.html

May 2018

2017 NC ABLES Summary

- Over six thousand adults were tested for blood lead in 2017
- 1 in 5 persons (nonpregnant) tested in 2017 had blood lead levels that were considered elevated
- The primary source of lead exposure was work
- Shooting firearms was found to be a primary source of nonwork-related lead exposure
- 99% of prenatal blood lead tests were below the level of concern for pregnant women

During 2017, the North Carolina Adult Blood Lead Epidemiology Surveillance (NC ABLES) Program received a total of 9,459 blood lead reports representing 6,200 people aged 16 years and older, including 1,006 pregnant women.

Among the 5,194 non-pregnant persons tested, 1,107 (21%) had an elevated BLL ≥5 µg/dL; 671 (13%) had a BLL ≥10 µg/dL, and 41 had a BLL ≥40 µg/dL.

The prevalence of elevated BLLs ≥5 µg/dL was 22 per 100,000 employed persons; the prevalence of BLLs ≥10 µg/dL was 14 per 100,000 employed persons.

Occupational exposures represented 97% of elevated BLLs with a known exposure source. The major industry sources of occupational exposure to lead continues to be Primary Battery Manufacturing (66%), Nonferrous Metal (Except Copper and Aluminum) Rolling, Drawing, and Extruding (7%), and Iron and Steel Mills (5%). For those with non-occupational lead exposure, shooting firearms (70%) was the primary source.

Among the 1,006 pregnant women tested, 14 women (1%) had a BLL ≥5 µg/d, only one of whom had a BLL ≥10 µg/dL. All women with BLLs ≥5 µg/dL received exposure prevention information.

Main Sources of Occupational and Non-occupational Lead Exposure in North Carolina

Occupational:
Primary Battery Manufacturing

Non-occupational:
Target Shooting

Background

The National Institute for Occupational Safety and Health (NIOSH) established the Adult Blood Lead Epidemiology and Surveillance Program (ABLES) in 1987 to identify and reduce the number of adults aged 16 years and older with elevated BLLs (NIOSH, 2015). In 1994, North Carolina started NC ABLES, a state-based program and enacted a mandatory reporting law (10A NCAC 41C .0701-.0703), which requires all commercial laboratories to report adult blood leads to the NC ABLES program. Results are compiled annually and shared with NIOSH. This initiative accelerates progress toward achieving the Healthy People 2020 objective of reducing the number of blood lead levels ≥10 µg/dL in adults (Office of Disease Prevention and Health Promotion, 2016). The ABLES program has successfully helped reduce the prevalence of elevated BLLs ≥25 µg/dL from 14.0 per 100,000 employed adults in 1994 to 2.9 per 100,000 employed adults in 2017.

During 2015, the Council of State and Territorial Epidemiologists (CSTE) and the Centers for Disease Control and Prevention (CDC) changed the definition of an elevated blood lead level (BLL) for adults from ≥10 µg/dL to ≥5 µg/dL (CTSE, 2015; CDC, 2016). For reference, the average blood lead level among US adults is about 1 µg/dL (CDC, 2014).

Individuals can be exposed to lead in both occupational and non-occupational settings through inhalation, ingestion, or, in rare cases, skin absorption of lead dust or fumes. Occupational lead exposure accounts for approximately 95% of all elevated BLLs in adults (Council of State and Territorial Epidemiologists, 2016). Several industries work with lead-based products including artistry, battery production, construction, mining, and plumbing. If proper personal hygiene is not performed, workers may bring lead home unintentionally on clothes, skin, or shoes exposing their family members. As stipulated by the OSHA Lead General Industry Standard (29 CFR 1910.1025) and the OSHA Lead in Construction Standard (29 CFR 1926.62) industries are required to have protocols in place to protect workers from lead (OSHA, 2016). Sources of non-occupational lead exposure include hobbies such as target shooting, casting fishing weights, and ceramics. Cooking from leaded cookware and drinking liquids containing lead, such as moonshine, can also play a role in exposure. The Environmental Protection Agency (EPA) publishes safe practices for citizens who may come in contact with lead (EPA, 2015).

Health effects from acute lead exposure are well-documented and, in general, the number and severity of symptoms worsen with increasing BLLs. With mild lead toxicity, symptoms may include mild fatigue, irritability, and sleep disturbances; moderate toxicity may produce headaches, greater fatigue, muscle aches and irritability, mental status changes, and gastrointestinal changes; and severe toxicity usually results in a medical emergency and may produce digestive disorders, peripheral neuropathy, and encephalopathy. Research indicates that health effects are also occurring at low levels of exposure (≤5 µg/dL) to include tremors, decrease in kidney function, increased blood pressure, and fertility and other reproductive issues (National Toxicology Program, 2012).

Elevated lead levels during pregnancy and breastfeeding have been associated with adverse maternal and infant health outcomes including gestational hypertension, spontaneous abortion, preterm delivery,

and impaired neurodevelopment of offspring (CDC, 2010). Lead readily crosses the placental barrier and has been detected in the developing fetal brain as early as the first trimester. In 2016, the NC State Laboratory of Public Health in cooperation with local health departments began offering free prenatal lead screening tests for women with identified risk factors for lead exposure. This initiative aligns with the Centers for Disease Control and Prevention (CDC) recommendations for the management of pregnant women with lead exposure. The BLL of concern for pregnant and lactating women is ≥ 5 µg/d (CDC, 2010).

To prevent occupational lead exposure in North Carolina, NC ABLES conducts the following activities.

- On a quarterly basis BLLs ≥10 µg/dL are shared with the NC Occupational Safety and Health Administration who uses them to guide compliance efforts with lead industries.
- Exposure prevention information is sent by mail to women of childbearing age and pregnant women with a BLL≥ 5 µg/dL, and to all others with a BLL ≥10 µg/dL
- NC ABLES staff attempt to interview adults with a BLLs ≥40 µg/dL to identify sources of lead exposure and provide counseling to reduce exposure.
- When employee BLLs reach or exceed 40 µg/dL, a state industrial hygienist calls the employer to discuss the exposure controls necessary to reduce occupational lead exposure. The industrial hygienist may also suggest conducting a site visit.
- For worker families with confirmed take-home lead exposure, exposure prevention information is sent by mail and employer visits are conducted for significant exposures in addition to interventions performed by the childhood lead program in the respective county.

Methodology

All BLLs received for NC residents aged 16 years or older during 2017 were included in this analysis. NC ABLES attempts daily follow-back with clinics and laboratories who draw blood lead specimens to obtain important demographic and occupational information missing from laboratory reports.

Elevated BLLs were classified and examined in the following categories:

- ≥ 5 µg/dL: The current ABLES reference BLL for US adults (as of November 2015)
- ≥ 10 µg/dL: The current public health action level for adults in North Carolina
- ≥ 25 µg/dL:
- ≥ 40 µg/dL: The BLL that the Occupational Safety and Health Administration recommends workers maintain at or below to avoid health effects; and, following medical exclusion from work, the BLL at which a worker is allowed to resume lead-related duties.

Although BLLs ≥ 5 µg/dL are reported here, the focus of the report are BLLs ≥ 10 µg/dL as this is the current level where public health action begins.

The distribution of demographic characteristics and reported exposure sources are described overall and by both occupational and non-occupational exposures. Incidence and prevalence of elevated BLLs were calculated during a five-year period (2013–2017) using the methods listed in the Council of State and Territorial Epidemiologists (CSTE) Occupational Health Indicators: A Guide for Tracking Occupational Health Conditions and Their Determinants (CSTE, 2016). BLLs for non-North Carolina residents were not included in the numerator for prevalence and incidence calculations. For the denominator, total employment was determined from the US Bureau of Labor Statistics for the respective years. During 2017, the total number of employed workers in North Carolina was 4,686,000.

This is the first NC ABLES report that includes BLLs among pregnant women. BLLs from pregnant women are described separately because testing, sources of exposure, and follow-up actions may differ from other adults and to preserve our ability to examine trends in BLLs over time.

Data were analyzed using SAS 9.4 and Microsoft Excel.

Results

During 2017, laboratories reported 9,459 blood lead reports; 8,448 from non-pregnant adults at least 16 years of age and 1,011 from pregnant women (Figure 1). These reports represent 6,200 people; 5,194 non-pregnant adults and 1,006 pregnant women.

Adults (non-pregnant)

Demographics

Among 5,194 persons tested, the average BLL was 4.4 µg/dL, and the median was 2.0 (range: 1–74 µg/dL). In total, 1,107 had at least one BLL ≥5 µg/dL, 671 (13%) had at least one BLL ≥10 µg/dL, 138 had at least one BLL ≥25 µg/dL (3%), and 41 had at least one BLL ≥40 µg/dL (1%) (Table 1). The majority of BLLs ≥5 µg/dL occurred among males (91%) and among 25–64-year-old persons (77%) (Table 2). Males also accounted for a disproportionately large proportion of those with BLLs ≥10 µg/dL (94%) and ≥40 µg/dL (100%).

Exposure Source

Among those who had a known exposure source (n = 909), 98% had a reported occupational exposure; 827 of whom reported the industry he/she works in. Workers in primary battery manufacturing accounted for the largest proportion of BLLs ≥10 µg/dL (379 of 527; 72%) (Figure 2). Nonferrous metal (except copper and aluminum) rolling, drawing, and extruding accounted for a small proportion of BLLs ≥ 10 µg/dL (6%), but 84% of persons with BLLs ≥40 µg/dL (Table A1).

Non-occupational exposure was rare, accounting for only 3% of persons tested with a reported exposure source. Target shooting was the activity that accounted for the largest proportion of non-occupational exposures (Table 3).

Incidence and Prevalence

The prevalence of elevated BLLs ≥ 5 µg/dL in 2017 was 23/100,000 employed persons; the incidence was 12/100,000 employed persons. The prevalence and incidence of elevated BLLs ≥10 µg/dL and 40 µg/dL are shown in Figures 3 & 4.

The geographic distribution of prevalence of BLLs ≥ 10 µg/dL based on reported county of residence is shown in Figure 5. The highest prevalence of BLLs ≥10 µg/dL were observed in the northwestern part of the state, with the highest prevalence in Forsyth County (74.9/100,000 people). This is most likely explained by the location of lead-acid battery manufacturing and related industries in this area of the state. Counts of elevated blood lead tests by county of exposure and residence are shown in Tables A2 and A3.

Pregnant Women

A total of 1,006 pregnant women in North Carolina had their blood lead tested in 2017. Among those tested, 14 had a BLL ≥ 5 µg/dL (Table 4) and were sent educational information by mail; only one woman had a BLL ≥ 10 µg/dL.

Conclusions

During 2017, the prevalence of persons with an elevated BLLs ≥10 µg/dL was 14.0/100,000 employed persons. This prevalence estimate was similar to what was observed during the previous four years among NC adults. The prevalence of BLLs ≥40 µg/dL, has also remained constant during this period. The prevalence of elevated BLLs ≥10 µg/dL in North Carolina, is slightly lower than the national prevalence of 19.1/100,000 employed persons from 26 reporting states in 2014 (CDC, 2018).

In November of 2015, ABLES lowered the reference BLL for US adults from 10 µg/dL to 5 µg/dL. During 2017, the prevalence of adults tested in North Carolina with a BLL ≥5 µg/dL was 23 per 100,000 employed persons. In the future, the NC ABLES program will continue to track BLLs exceeding this new reference value.

Primary Battery Manufacturing continues to be the industry that accounts for most of the occupational exposure in North Carolina (NC ABLES, 2015) and is among the top industries for lead exposure in the United States (NIOSH, 2015). Battery manufacturing and related industries are concentrated in the northwestern part of the state. During 2016–2018, NC DHHS has used NC ABLES data to identify multiple industries related to battery manufacturing in Forsyth County and has joined the Forsyth County Health Department in working to address lead exposure among workers in these industries.

Among persons with elevated BLLs ≥5 µg/dL associated with non-occupational exposure sources, target shooting was the most common source of lead exposure. This is similar to findings in North Carolina in previous years (NC DHHS, 2015) and national estimates (Beaucham et al., 2014).

Priorities for outreach continue to include the battery manufacturing industry and nonferrous metal (except copper and aluminum) rolling drawing industry. Outreach to these industries will inform employees and employers on: how to reduce exposure and lower blood lead levels; available science regarding chronic, low-level lead exposure and the resulting health effects; and the dangers of take-home lead exposure and the impact it can have on family members and friends.

Outreach to firing ranges will also be prioritized. If firing ranges are not properly ventilated, target shooters can unknowingly be exposed to lead. Appropriate outreach to range operators should include information about checking ventilation systems every three months to prevent exposure to lead dust and fumes during firearm use (National Shooting Sports Foundation, 2015).

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Figures & Tables

Figure 1. Blood Lead Reports Received by the NC ABLES program—North Carolina, 2013–2017.

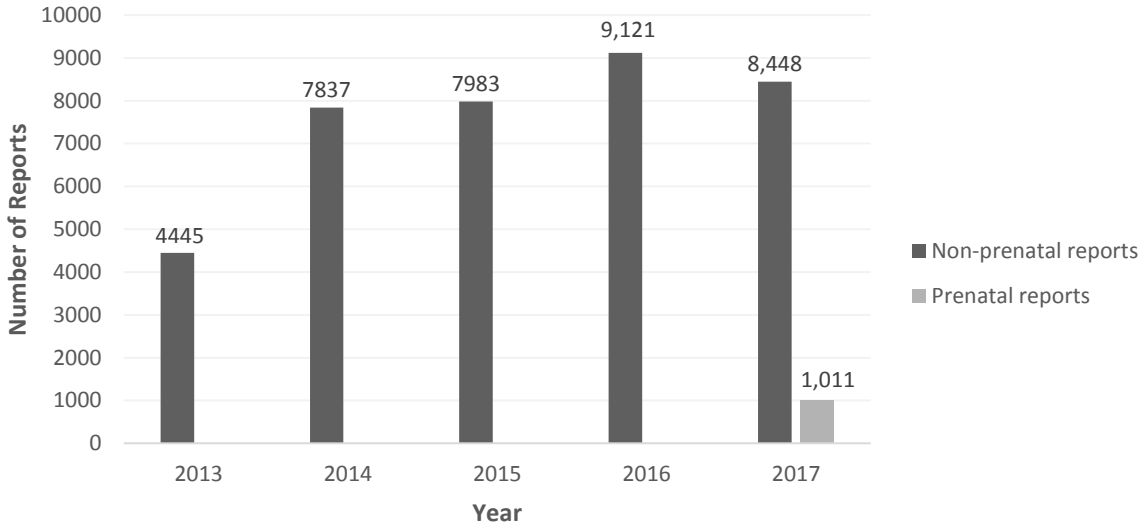


Figure 2. Number of BLLs ≥10 µg/dL by Industry Type —North Carolina, 2017.

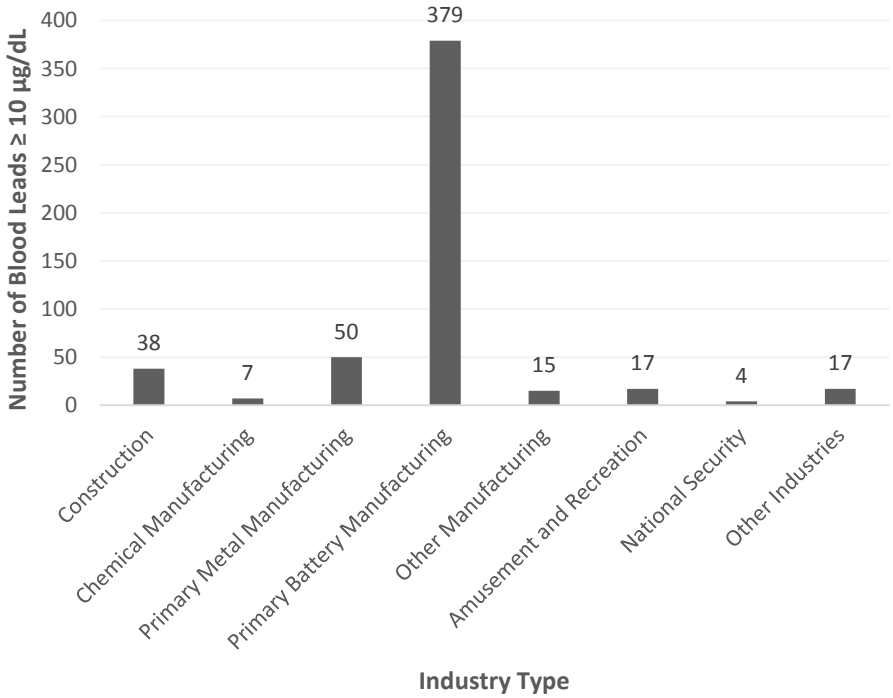


Figure 3. Prevalence of Highest Blood Lead Levels ≥10 µg/dL and ≥40 µg/dL per 100,000 Employed Persons—North Carolina, 2013–2017 (Non-prenatal).

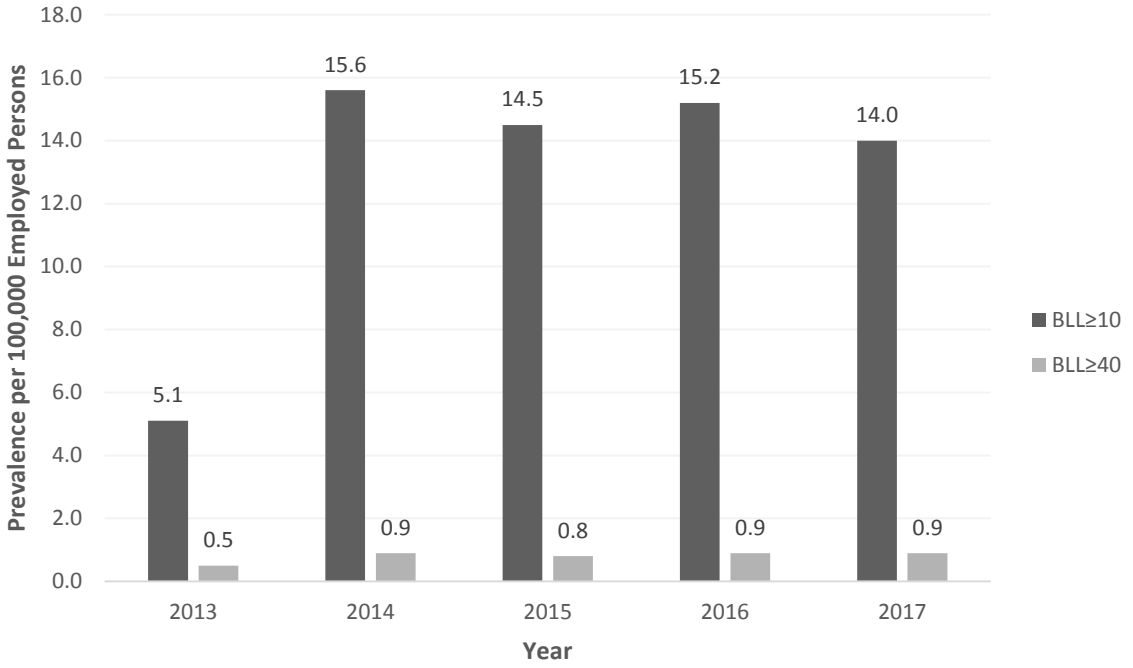


Figure 4. Incidence of Highest Blood Lead Levels ≥10 µg/dL and ≥40 µg/dL per 100,000 Employed Persons in NC—North Carolina, 2013–2017 (Non-prenatal).

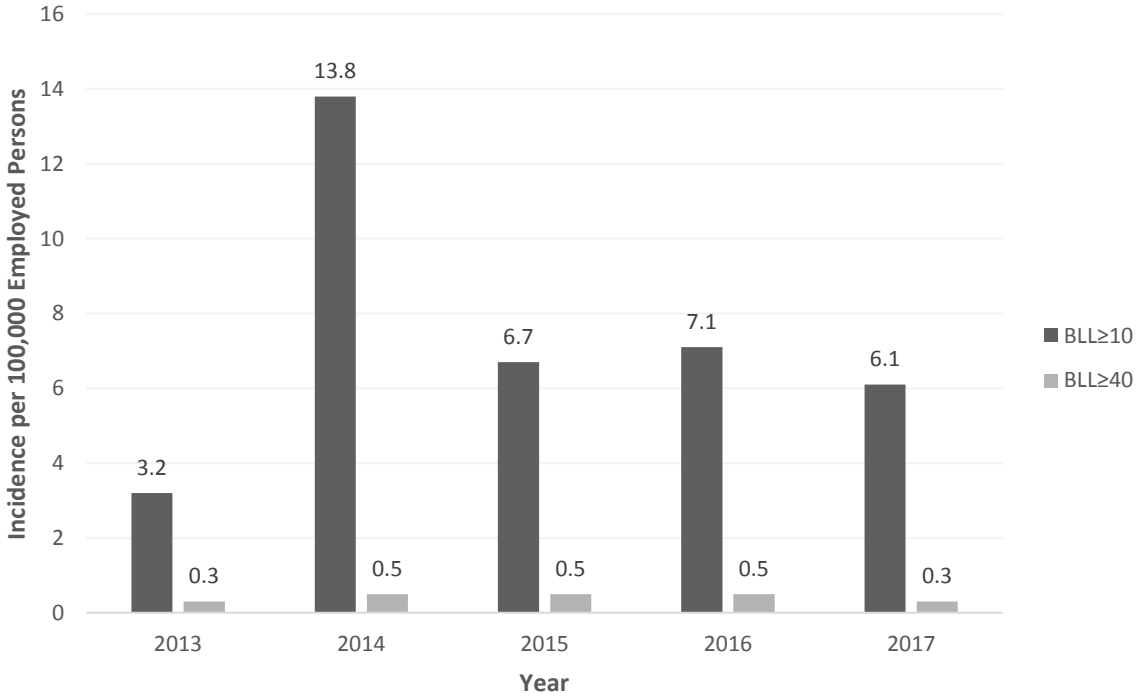
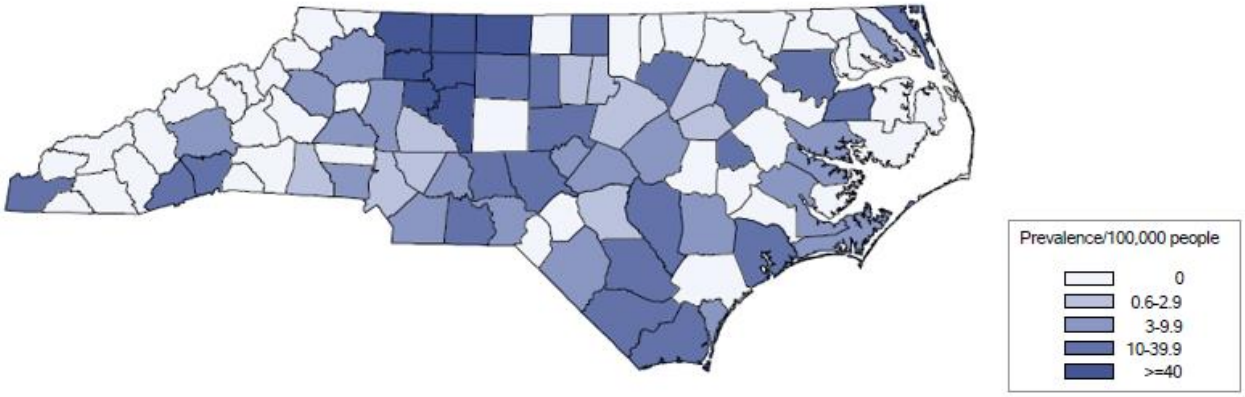


Figure 5. Prevalence of Blood Lead Levels ≥10 µg/dL per 100,000 Persons by County of Residence*— North Carolina, 2013–2017 (Non-prenatal).



*County of residence was missing for 86 people (13%).

Table 1. Distribution of Highest Blood Lead Levels Among NC Residents ≥16 years old—North Carolina, 2017 (Non-prenatal).

BLL (µg/dL)	All		Occupational		Non-Occupational		Unknown	
	Count	%*	Count	%*	Count	%*	Count	%*
<5	4087	79	212	24	0	0	3875	90
5-9	436	8	132	15	0	0	304	7
10-24	533	10	425	48	17	74	91	2
25-39	97	2	78	9	5	22	14	0.3
40-59	36	0.7	34	4	1	4	1	0.02
≥ 60	5	0.1	5	0.6	0	0	0	0
Total	**5194**		**886**		**23**		**4285**	

* Percentages shown are column percentages.

Table 2. Distribution of Age and Sex Among Adults Tested for Blood Lead—North Carolina, 2017 (Non-prenatal).

Characteristic	BLL (µg/dL)							
	All		≥5		≥10		≥40	
	Count	%*	Count	%*	Count	%*	Count	%*
Age[†] (Years)								
16-24	379	7	80	7	49	7	9	22
25-34	970	19	239	22	146	22	12	29
35-44	1006	20	218	20	135	20	7	17
45-54	1030	20	255	24	169	26	8	20
55-64	911	18	213	20	132	20	4	10
65+	824	16	78	7	32	5	1	2
Total	**5120**		**1083**		**663**		**41**	
Sex[‡]								
Male	3653	71	1002	91	632	94	41	100
Female	1516	29	100	9	38	6	0	0
Total	**5169**		**1102**		**670**		**41**	

*Percentages shown are column percentages.
[†]Age was unknown for 74 individuals.
[‡] Sex was unknown for 25 individuals.

Table 3. Distribution of Reported Exposure Sources for Non-Occupational Lead Exposure*—North Carolina, 2017 (Non-prenatal).

Non-Occupational Exposure Sources	BLL (µg/dL)					
	All		≥ 10		≥ 40	
	Count[+]	%*	Count	%[‡]	Count	%[‡]
Shooting firearms (target shooting)	16	70	16	70	1	100
Casting (e.g., bullets, fishing weights)	3	13	3	13	0	0
Retained bullets (gunshot wounds)	2	9	2	9	0	0
Retired from military	1	4	1	4	0	0
Drinking water	1	4	1	4	0	0

*Exposure source unknown for 2 individuals with non-occupational lead exposure.
[+] One individual reported two categories of exposure and is counted in both.
[‡]Percentages shown are column percentages.

Table 4. Distribution of Highest Blood Lead Levels Among **Pregnant Women** Tested—North Carolina, 2017.

BLL (µg/dL)	Prenatal Blood Leads	
	Count	%*
<5	992	99
5-9	13	1
10-24	1	0.1
≥ 25	0	0
Total	**1006**	

[‡]Percentages shown are column percentages.

APPENDIX

Table A1. Distribution of Occupational Lead Exposure by Industry Title*—North Carolina, 2017 (non-prenatal).

NAICS Code†	Industry Title	BLL (µg/dL)					
		All		≥ 10		≥ 40	
		Count	%‡	Count	%‡	Count	%‡
212399	All Other Nonmetallic Mineral Mining	4	0.5	3	0.6	1	2.7
23	Construction	1	0.1	1	0.2	0	0.0
236115	New Single-Family Housing Construction (except For-Sale Builders)	1	0.1	1	0.2	0	0.0
236220	Commercial and Institutional Building Construction	6	0.7	5	1.0	0	0.0
237130	Power and Communication Line and Related Structures Construction	1	0.1	1	0.2	0	0.0
237310	Highway, Street, and Bridge Construction	13	1.6	10	1.9	1	2.7
238120	Structural Steel and Precast Concrete Contractors	18	2.2	0	0	0	0.0
238220	Plumbing, Heating, and Air-Conditioning Contractors	3	0.4	3	0.6	0	0.0
238290	Other Building Equipment Contractors	6	0.7	6	1.1	1	2.7
238320	Painting and Wall Covering Contractors	12	1.5	7	1.3	0	0.0
238910	Site Preparation Contractors	3	0.4	2	0.4	0	0.0
238990	All Other Specialty Trade Contractors	8	1.0	2	0.4	0	0.0
311111	Dog and Cat Food Manufacturing	1	0.1	0	0.0	0	0.0
325132	Synthetic Organic Dye and Pigment Manufacturing	11	1.3	0	0.0	0	0.0
325199	All Other Basic Organic Chemical Manufacturing	1	0.1	1	0.2	0	0.0
325211	Plastics Material and Resin Manufacturing	22	2.7	0	0.0	0	0.0
327211	Flat Glass Manufacturing	6	0.7	6	1.1	1	2.7
331111	Iron and Steel Mills	45	5.4	2	0.4	0	0.0
331491	Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	54	6.5	48	9.1	31	83.8
332312	Fabricated Structural Metal Manufacturing	5	0.6	5	0.1	0	0.0

NAICS Code†	Industry Title	BLL (µg/dL)					
		All		≥ 10		≥ 40	
		Count	%	Count	%	Count	%
332322	Sheet Metal Work Manufacturing	4	0.5	2	0.4	0	0.0
332994	Small Arms, Ordnance, and Ordnance Accessories Manufacturing	4	0.5	4	0.8	0	0.0
332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	1	0.1	1	0.2	0	0.0
333513	Machine Tool (Metal Forming Types) Manufacturing	2	0.2	2	0.4	0	0.0
335911	Storage Battery Manufacturing	2	0.2	1	0.2	0	0.0
335912	Primary Battery Manufacturing	549	66.4	379	71.9	2	5.4
423930	Recyclable Material Merchant Wholesalers	1	0.1	0	0.0	0	0.0
488490	Other Support Activities for Road Transportation	4	0.5	4	0.8	0	0.0
561720	Janitorial Services	4	0.5	3	0.6	0	0.0
562211	Hazardous Waste Treatment and Disposal	1	0.1	1	0.2	0	0.0
562910	Remediation Services	1	0.1	1	0.2	0	0.0
562991	Septic Tank and Related Services	2	0.2	2	0.4	0	0.0
611310	Colleges, Universities, and Professional Schools	1	0.1	0	0.0	0	0.0
611620	Sports and Recreation Instruction	1	0.1	1	0.2	0	0.0
713990	All Other Amusement and Recreation Industries	19	2.3	17	3.2	0	0.0
811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	1	0.1	0	0.0	0	0.0
922120	Police Protection	4	0.5	2	0.4	0	0.0
928110	National Security	5	0.6	4	0.8	0	0.0
	Total	**827**		**527**		**37**	

*NAICS Code unknown for 59 individuals with occupational lead exposure

†North American Industry Classification System

‡Percentages shown are column percentages.

Table A2. Distribution of County of Exposure* Among Adults Tested for Blood Lead in NC—North Carolina, 2017 (non-prenatal).

County	BLL (µg/dL)					
	All		≥ 10		≥ 40	
	Count	%‡	Count	%‡	Count	%‡
Forsyth	601	73.0	432	85.0	33	91.7
Guilford	16	1.9	13	2.6	1	2.8
Mecklenburg	15	1.8	5	1.0	0	0.0
New Hanover	12	1.5	11	2.2	1	2.8
Onslow	9	1.1	9	1.8	0	0.0
Rockingham	6	0.7	6	1.2	0	0.0
Wake	21	2.6	5	1.0	0	0.0
Other Counties	31	0.04	27†	5.3	1	2.8
Total	**823**		**508**		**36**	

*County of residence was unknown for 4,371 individuals overall and for 163 individuals with BLLs ≥ 10 µg/dL.

†15 Other Counties had less than 5 individuals with elevated blood lead levels each.

‡Percentages shown are column percentages.

Table A3. Distribution of County of Residence* Among Adults Tested for Blood Lead in NC—North Carolina, 2017 (non-prenatal).

County	BLL (µg/dL)					
	All		≥ 10		≥ 40	
	Count	%	Count	%	Count	%
Alamance	47	1.5	7	1.2	2	4.9
Beaufort	10	0.3	5	0.9	1	2.4
Brunswick	83	2.6	8	1.4	0	0
Buncombe	182	5.7	12	2.1	1	2.4
Catawba	37	1.2	5	0.9	0	0
Davidson	69	2.1	30	5.1	4	9.8
Davie	14	0.4	6	1.0	1	2.4
Forsyth	538	16.7	279	47.7	21	51.2
Gaston	73	2.3	5	0.9	1	2.4
Guilford	151	4.7	46	7.9	3	7.3
Iredell	52	1.6	5	0.9	0	0
Mecklenburg	248	7.7	9	1.5	0	0
New Hanover	64	2.8	11	1.9	1	2.4
Onslow	87	2.7	14	2.4	0	0
Rockingham	37	1.2	12	2.1	0	0
Stokes	46	1.4	24	4.1	0	0
Surry	30	0.9	14	2.4	1	2.4
Wake	190	5.9	14	2.4	0	0
Yadkin	17	0.5	12	2.1	1	2.4
Other Counties	1246	38.7	67[†]	11.5	4	9.8
Total	**3221**		**585**		**41**	

*County of residence was unknown for 1,973 individuals overall and for 186 individuals with BLLs ≥ 10 µg/dL.

[†]38 Other Counties had less than 5 individuals with elevated blood lead levels each.

[‡]Percentages shown are column percentages.