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BACKGROUND

Despite significant reductions in lead exposure in the United States, elevated blood lead levels (EBLLs) in adults remain a significant occupational health problem. According to the Centers for Disease Control and Prevention (CDC), about 95% of EBLLs in adults are related to their work. Lead is used in over 100 industries. Lead exposure occurs mainly in the battery manufacturing, foundry, lead and zinc ore mining, and painting and construction/restoration industries (1). The Occupational Safety and Health Administration (OSHA) regulates lead exposure in industrial settings at ≥ 40 $\mu\text{g}/\text{dL}$.

Over the last 18 years, a 54% decrease in the national prevalence rates of EBLL greater than or equal to 25 micrograms per deciliter ($\geq 25\mu\text{g}/\text{dL}$) has been documented using the National Institute for Occupational Safety and Health (NIOSH) Adult Blood Lead Epidemiology and Surveillance (ABLES) data. Despite this decrease, current ABLES data indicate that lead exposure at all levels remains a national occupational health problem (in 2010, ABLES reported 31,459 new adult cases in the United States with EBLLs ≥ 10 $\mu\text{g}/\text{dL}$; among these, 1,388 had EBLLs ≥ 40 $\mu\text{g}/\text{dL}$) and that continued efforts to reduce lead exposures are needed (2).

Adverse health effects have been found with cumulative exposure at EBLLs < 25 $\mu\text{g}/\text{dL}$ (3). Lead adversely affects multiple organ systems and can cause permanent damage. Exposure to lead in adults can cause anemia, nervous system dysfunction, kidney damage, hypertension, decreased fertility, and miscarriage (4–11).

As a result of this evidence, NIOSH has designated 10 $\mu\text{g}/\text{dL}$ of whole blood as the reference blood lead level for action in adults. In 2009, the Council for State and Territorial Epidemiologists (CSTE) made the same recommendation. The U.S. Department of Health and Human Services recommends that EBLLs among all adults be reduced to < 10 $\mu\text{g}/\text{dL}$. Medical management guidelines for lead-exposed adults now recommended action for EBLLs ≥ 10 $\mu\text{g}/\text{dL}$ (12). Finally, the Healthy People 2020

occupational health goal for adult lead has been revised to reduce EBLLs of 10 $\mu\text{g}/\text{dL}$ or greater in all persons aged 16 years and older.

Currently, the Healthy Homes and Lead Poisoning Prevention Program (HHLPPP) at the Division of Public Health Services in the New Hampshire Department of Health and Human Services receives all adult blood lead reports for New Hampshire residents from labs and medical providers in accordance with State law. For all EBLLs ≥ 25 $\mu\text{g}/\text{dL}$, a report is sent to the NIOSH ABLES system for inclusion in national estimates. Adult blood lead levels ≥ 40 $\mu\text{g}/\text{dL}$ are reported to the Occupational Safety and Health Administration (OSHA), as per the federal OSHA Lead Standard.

This study was conducted in order to better characterize blood lead levels in the New Hampshire adult working population. The objective is to gain additional insights into the occupational risk for lower level exposures to lead.

METHODS

New Hampshire adult blood lead results ≥ 10 $\mu\text{g}/\text{dL}$ were analyzed for the years 2009–2013 ($n=650$) by blood lead level and industry type. Information was collected using the HHLPPP surveillance database. The data included gender, age, blood lead level, and employer industry. For cases where no employer information was listed on the report, the HHLPPP staff made phone calls to providers and laboratories to collect occupation and employer information for patients where it was available.

The cases were ordered by client ID number, and duplicate tests were removed. The final data set contained 650 cases, and reflected the highest blood lead result available for a patient within the time period of 2009–2013. Data were analyzed by age, gender, and blood lead level. Blood lead levels were split into two groups: 10–24 $\mu\text{g}/\text{dL}$ and ≥ 25 $\mu\text{g}/\text{dL}$ (with some distribution analysis at 40 $\mu\text{g}/\text{dL}$ and higher).

Employment information was obtained for 458 of the 650 cases. This includes patients listed as self-employed,

retired, unemployed, and deceased. The 2012 North American Industry Classification System (NAICS) codes were used to categorize each case by industry. The NAICS

General Industry Category was determined by the first 2 digits of the NAICS code for the employer.

RESULTS

Figure 1 shows the yearly number of New Hampshire adults aged greater than 16 years old that had a blood lead level ≥ 10 $\mu\text{g}/\text{dL}$ from 2009 to 2013. In 2013, 106 such cases were identified in New Hampshire.

Figure 1: Number of Elevated Blood Lead Levels (≥ 10 $\mu\text{g}/\text{dL}$) in NH Adults, 2009-2013

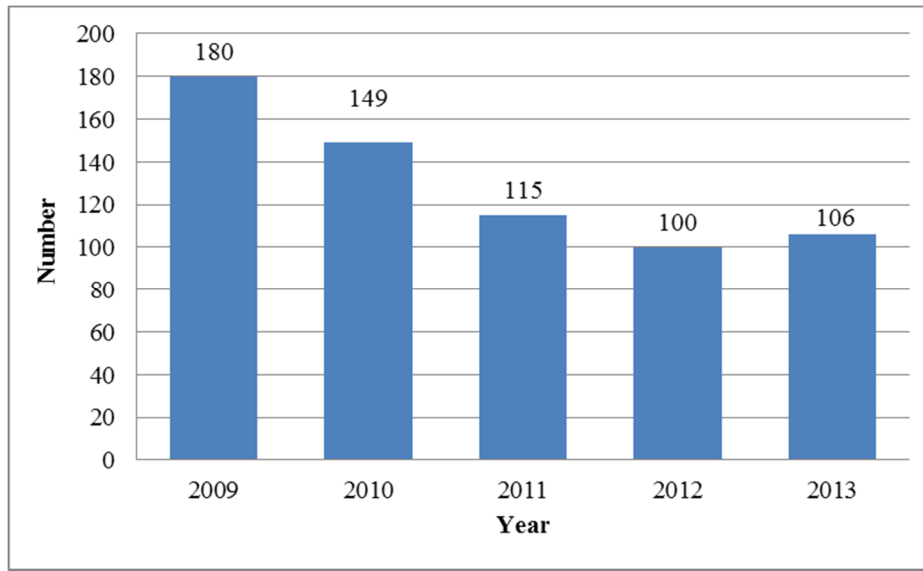


Table 1 shows the percentage breakdown of EBLLs for each year from 2009 to 2013. Over the 5-year period, approximately 90% of cases represented lower blood lead levels between 10- 24 $\mu\text{g}/\text{dL}$ and nine percent of cases represented EBLLs 25 - 39 $\mu\text{g}/\text{dL}$. Only 1% of cases were at or above the OSHA exposure limit of 40 $\mu\text{g}/\text{dL}$. Of the 106 cases in 2013, 95% represented EBLLs between 10 - 24 $\mu\text{g}/\text{dL}$ and 5% of the cases in 2013 represented EBLLs ≥ 25 $\mu\text{g}/\text{dL}$.

Table 1: Blood Lead Test Results by Level, 2009 - 2013

Year	Blood Lead Level Test Result						Total No. of Cases for Year
	10 - 24 $\mu\text{g}/\text{dL}$		25 - 39 $\mu\text{g}/\text{dL}$		≥ 40 $\mu\text{g}/\text{dL}$		
	No. of cases	% of total cases	No. of cases	% of total cases	No. of cases	% of total cases	
2009	162	90%	16	9%	2	1%	180
2010	128	86%	18	12%	3	2%	149
2011	103	90%	10	9%	2	2%	115
2012	88	88%	12	12%	0	0%	100
2013	101	95%	4	4%	1	1%	106
Total	582	90%	60	9%	8	1%	650

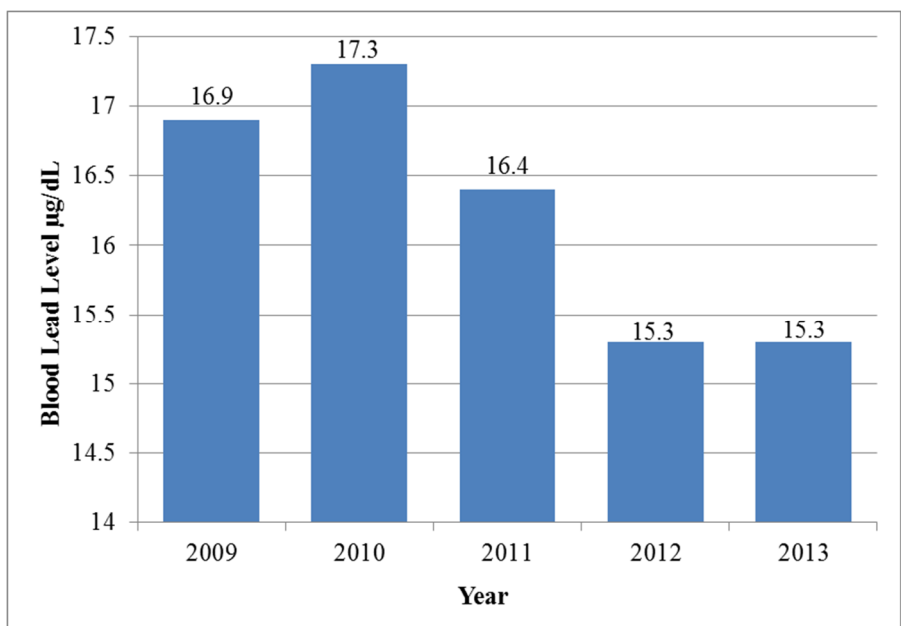
Table 2 shows the distribution of lead levels by gender and age group from 2009 to 2013. Of the 650 adult cases, almost 25% (n=161) were between 51 and 60 years old, while 21% (n=138) were between 21 and 30 years old. For the 33 female cases, 33% (n=11) occurred between the ages of 51-60. Among males of all ages, only 11% (n=67) of cases represented EBLs > 25 µg/dL. For females of all ages, only 3% (n=1) of cases represented EBLs > 25 µg/dL. The gender distribution of all adults with EBLs >10 µg/dL from 2009–2013 was 95% (n=617) male and 5% (n=33) female.

Table 2: Lead Test Results by Gender and Age, 2009–2013

Age Group (Years)	Blood Lead Level Test Result				Total No. of Cases for Age Group
	10- 24 µg/dL		≥25 µg/dL		
	No. of Males	No. of Females	No. of Males	No. of Females	
16 to 20	11	1	3	0	15
21 to 30	124	6	7	1	138
31 to 40	100	4	10	0	114
41 to 50	115	6	14	0	135
51 to 60	128	11	22	0	161
61 and up	72	4	11	0	87
Total	550	32	67	1	650

Figure 2 shows average EBLs by year. On average, blood lead levels in 2013 were 15.3 µg/dL, which is 5 µg/dL higher than the 10 µg/dL level at which adults are recommended action be taken to reduce the BLL.

Figure 2: Average Blood Lead Level of those Adults Tested, by Year, 2009–2013



Of the 650 total adult cases, 192 had an unknown employer; 26 were self-employed; and 21 were deceased, disabled, not employed, or retired by the time the HHLPPP collected the information from the provider and/or lab. **Table 3** shows a breakdown of EBLLs by industry for the 411 adults for whom employer information was available. Forty three percent (n=175) were in the manufacturing industry and 28% (n=116) were in the construction industry at the time of their blood lead test. For each industry, fewer than 50% of reported cases reflected EBLLs ≥ 25 $\mu\text{g}/\text{dL}$.

Table 3: Lead Test Results by General Industry, 2009–2013

NAICS General Industry	Blood Lead Level Test Result		Total No. of Cases for Industry
	10- 24 $\mu\text{g}/\text{dL}$	≥ 25 $\mu\text{g}/\text{dL}$	
	No. of cases	No. of cases	
Manufacturing	161	14	175
Construction	103	13	116
Waste Management and Remediation Services	57	4	61
Repair and Maintenance Services	13	1	14
Wholesale Trade	6	5	11
Professional, Scientific, and Technical Services	7	0	7
Transportation and Warehousing	7	0	7
Educational Services	5	0	5
Public Administration	3	0	3
Retail Trade	2	1	3
Utilities	3	0	3
Arts, Entertainment, and Recreation	2	0	2
Information	2	0	2
Finance and Insurance	1	0	1
Real Estate and Rental and Leasing	1	0	1
Total	373	38	411

Table 4 shows ten industry subcategories with the highest number of adults with elevated blood lead levels (EBLLs 10–24 µg/dL and ≥25 µg/dL). Industry text for each NAICS code was used to categorize employers. One hundred thirty adults were employed in the foundries, valves, and inline plumbing and heating industry at the time of blood lead testing, which is more than double the number employed in any other industry. Another 50 adults were employed in bridge and highway industries, 47 in firearms, and 44 in environmental remediation services.

Table 4: Lead Test Results by Top 10 Industry Subcategories, 2009–2013

NAICS Industry Text	Blood Lead Level Test Result		Total No. of Cases for Industry
	10- 24 µg/dL	≥25 µg/dL	
	No. of cases	No. of cases	
Foundries, Valves and Inline Plumbing and Heating	117	13	130
Bridge and Highway Painting/Construction	40	10	50
Firearms, Ammunition Manufacturing and Wholesale	41	6	47
Environmental remediation services	42	2	44
Residential Construction and Renovation	15	0	15
Waste recovery facilities	13	1	14
Antique furniture repair and restoration shops	7	1	8
Acid plant construction	4	0	4
Door and Window Installation	4	0	4
Heating boiler installation	4	0	4

LIMITATIONS

The collection of elevated adult blood lead cases is based on provider testing of BLLs prompted by a work-related exposure or regulatory requirements. It therefore does not represent all workers in New Hampshire with exposure to lead. For this reason, we are unable to calculate rates based on how many workers there are in New Hampshire. Another critical limitation is the large number of cases with unknown occupation and employer information. Additionally, much of the employer information collected from labs and providers contained patient self-reported data at the time of the test, which may not accurately reflect actual employment status or occupation of the patient.

DISCUSSION

While New Hampshire is a small state, it is concerning that over 100 people are at risk for adverse health effects from exposure to lead each year. The majority of adults in our study have a BLL between 10 and 24 mcg/dL, with an average 5 mcg/dL greater than the recommended level at

which adults should have intervention to reduce BLL. The presence of lower EBLLs was most significant in males of all ages. Adults employed in the manufacturing and construction industries, foundries, painting, and firearms represented a large number of these lower EBLLs.

Our analysis indicates that long-term lead exposure continues to be a problem in our New Hampshire businesses and industries. OSHA rules impact those with EBLLs >40 µg/dL, however, no such regulation protects those with lower blood lead levels. OSHA regulations have also not been changed substantially since the late 1970s and thus are primarily based on health studies from over three decades ago. **Therefore the current occupational standards are not sufficiently protective and should be strengthened.**

Adult exposure to lead at work also has implications for the worker’s family, especially children, through the possibility of “take-home” lead. Even small amounts of lead can pose a serious threat to the health and development of young children.

State adult lead programs often do not have the resources to follow up on all adult lead cases in their states. Funding cuts in the Adult Blood Lead Epidemiology and Surveillance (ABLES) program has impacted states' ability to collect, code, and analyze data for lower EBLs, including industry information. Intervention activities with individuals, worksites, and others are also impacted. The loss of surveillance support to identify worker exposures will mean fewer referrals to OSHA and a lack of identifying and addressing lead and other workplace hazards. Surveillance identifying worker exposures in industries with little or no OSHA oversight (e.g., small radiator shops, firing ranges, renovation work) and emerging technologies (e.g., electronics recycling) will leave these workplaces and hazards unidentified as well (13).

With the knowledge we now have about the health impact of chronic low level exposure to lead, it is critical that public health experts work with occupational health and safety professionals to not only monitor adults for lead exposure but to also ensure that adequate protections are in place. This includes support of medical staff who can assist with tracking, monitoring, and reporting all adult lead cases, with a focus on follow-up to ensure appropriate protections are taken to reduce or eliminate the risk. Ultimately, however, permissible exposure levels in the workplace need to be reduced in

order to provide the most effective protection at the source of exposure.

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