Blood Lead Levels in Construction Workers Performing Lead Abatement

by
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ABSTRACT

MORAN, PATRICK. Blood Lead Levels in Construction Workers Performing Lead Abatement. (Under the direction of Dr. Jennifer Richmond-Bryant).

Lead abatement is a common practice in the construction industry. However, the job task generates airborne particulate lead, creating a potential workplace hazard exposure for workers if not managed properly. This exposure can cause severe acute and chronic illnesses. Entry and exit blood lead levels (BLLs) are required for all abatement workers under medical surveillance in OSHA § 1910.1025 Appendix C. BLLs can be used as a measurement of a worker's exposure. The change from entry to exit BLLs can be analyzed in different project settings, abatement methods, engineering controls, and job trades to help determine best practices in mitigating a worker's exposure. The Sen et al. (2002), Sokas et al. (1997), Levin et al. (1998), and Reynolds et al. (1999) studies all used different abatement methods for different abatement projects. Sen et al. (2002) analyzed scaffolders who performed mobilization/ demobilization erecting scaffolds in and around the containment while abrasive blasting was being performed. Sokas et al. (1997) studied crews who performed demolition and burning lead abatement versus workers who never performed demolition and burning lead abatement. Levin et al. (1998) compared BLL for iron workers on a bridge rehabilitation project in New York between the years 1993 and 1994 performing needle gunning and pneumatic chipping. Reynolds et al. (1999) compared the changes of BLL in construction workers in Iowa and Illinois across several different job occupations of laborers, painters, welders, and ironworkers. The findings of all four articles discovered that scaffold workers who were not performing active abatement tasks, such as mobilization and demobilization, could still have elevated BLL when working with containments or working in close proximity without necessary PPE. These four studies have unique abatement tasks and different engineering controls, despite there being increased BLL across tasks.

Additionally, three abatement projects in 2018-2020 in New York (Manhattan Subway Project, Yonkers Pump Station Wastewater Treatment Project, and Hastings-On-Hudson Bridge Project) also used different abatement methods for different projects. All three projects also exhibited workers having varied increased BLLs. Abrasive blasting, needle gunning, plasma cutting, lead tape removal, mobilization/demobilization, and vacuuming were the tasks performed at the projects. The needle gunning, plasma cutting, lead tape removal, and mobilization/demobilization had the lowest BLL while abrasive blasting and vacuuming had the highest BLL. A literature review of the four articles was performed and each article had unique conditions and different abatement methods, similar to the three projects having different conditions and abatement methods. The data from the articles were compared to the data in the three projects. Based on findings presented in Sen et al. (2002), Sokas et al. (1997), Levin et al. (1998), and Reynolds et al. (1999) and the results from three abatement projects, workers' risk of exposure exists regardless of abatement method but can be better managed by understanding which abatement methods and engineering controls should be used as best practice.

BIOGRAPHY

Patrick William Moran was born and raised in Mahwah, NJ. He attended Don Bosco Preparatory High School where he found his interest for the environmental science field. He graduated with a Bachelor of Science in Environmental Science (Concentrating in Sustainability Studies) and a minor in Political Science from Muhlenberg College in 2017. Immediately after college, he began working for a large hazardous waste management company where he oversaw the New Jersey branch operations of a client. In 2018, he changed career paths and moved to New York City. He began working for a civil engineering, construction project management general contracting company. He currently overseas all environmental aspects of all projects in the New York City area from the planning phase to full completion. While working full-time, Patrick began the Master of Environmental Assessment program in September 2019 and is on track to earn his degree in December 2022.

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Introduction

Lead based paint was widely used in both construction and residential settings until it was banned in New York in 1960 and then federally banned in 1978 (Local Law 66. §27-2056.1 ET SEQ). However, many structures are still encased with the original coats of lead-based paint, which create potential environmental and human health hazards. Lead paint was applied on 89% of all steel bridges in the United States, and many still have this coating (Levin, et al. 1998).

Workers in the construction industry are exposed to different hazards every day. Exposure to airborne particulate lead during lead abatement operations can cause negative short- and long-term health effects in adults. Short term health effects include fatigue, headache, nausea, and abdominal pains. (Hipkins et al. 1998). Long term effects can lead to chronic illnesses including kidney failure, hypertension, impaired visual and motor skills, and renal disease. (Hipkins et al. 1998).

To reduce workplace exposures, OSHA created the hierarchy of controls approach (Guth, et al. 2020). The hierarchy of controls under OSHA is a compounding tiered framework of hazard elimination methods with the most effective being elimination/ substitution of the hazard, second most effective being engineering controls to mitigate the workers' exposure to the risk, third most effective is administrative controls to limit the time spent around the hazard, and the final level of protection being the workers' personal protective equipment (PPE) as the workers' absolute line of defense against a hazard. Specifically, the OSHA lead construction standard, § 1910.1025, uses this risk management framework (Guth et al. 2020). The hierarchy of controls for lead abatement work would be as follows: eliminate/ substitute the hazard by performing lab analysis to rule out the potential for lead, engineering controls such as mechanical ventilation to bring fresh clean air into the work area/ containment, administrative controls such as shorter abatement shifts with job rotation to limit time spent exposed to airborne particulate lead, and provide workers with the clean necessary PPE, especially a respirator with the correct cartridges. Under OSHA § 1910.1025 Appendix C, medical surveillance is required for lead abatement work. Blood lead levels, or BLL, are to be measured prior to the start of work, at the conclusion of abatement work, and every six months if the project is longer than six months (OSHA 1910.1025 App C). BLL can be used as a measurement of a worker's exposure to lead, specifically which task, engineering controls, or PPE could lead to higher lead exposure (Abbas Virji et al. 2008).

Lead abatement is a common practice in the construction industry. Construction projects involve multiple tasks with multiple crews performed throughout the duration of the project, including lead abatement, which is the process of removing existing lead paint on a structure (Reames, et al. 2001). There are several different methods to abate lead-based paint on structures. The most common methods include abrasive blasting, needle gunning, lead tape removal, scraping, chemical stripping, and wet-block sanding (Reames, et al. 2001). Under OSHA 1910.1025(e)(1), engineering and administrative controls shall be in place to reduce and maintain employee exposure to lead, as well as to provide adequate PPE (OSHA 1910.1025 (e)(1)). Engineering controls including mechanical ventilation, power tools with shrouds, and vacuum blasting nozzles are commonly used to limit worker's exposure. Administrative controls such as shift substitution can be used in conjunction with the engineering controls. Administrative controls are put in place to limit the amount of time a worker is exposed to the hazard. PPE including respirators, gloves, and Tyvek suits are the worker's last line of defense against workplace exposure to lead.

Despite the use of engineering, administrative controls, and PPE, workers have been shown to have elevated BLL. However, modern abatement methods reduce exposure for workers. Sen et al. (2002), Sokas et al. (1997), Levin et al. (1998), and Reynolds et al. (1999) articles analyze BLL taken from different projects, abatement methods, and trades. Sen et al. (2002) analyzed the lead exposure of 27 scaffold workers using BLL. The authors discovered that scaffold workers who were not performing active abatement tasks, such as mobilization and demobilization, could still have elevated BLL when working with containments or working in close proximity without necessary PPE. Sokas et al. (1997) compared BLL across construction workers in Maryland who have and have not performed demolition lead abatement tasks, as well as workers who have and have not performed burning/welding abatement tasks. Sokas et al. (1997) determined ironworkers and welders who have performed abatement before had a greater change in BLL than the workers who had never performed abatement prior to the project before. Levin et al. (1998) compared BLL for iron workers on a bridge rehabilitation project in New York between the years 1993 and 1994. In both years, the ironworkers had a similar change in BLL and described the importance of using medical surveillance as an indicator of the effectiveness of engineering controls. Reynolds et al. (1997) shows the changes of BLL in construction workers in Iowa and Illinois across several different job tasks. Laborers had the biggest change in BLL, followed by the painters, welders, and ironworkers. These four studies have unique abatement tasks and different engineering controls, despite there being increased BLL across tasks. The articles all showed the workers having increased BLL from their lead abatement tasks. The lead abatement work industry would benefit from an updated assessment of BLL of workers performing remediation to show how lead exposure has changed since the ban on lead-based paint with the use of OSHA engineering controls and compliance with OSHA

1910.1025 and Society of Protective Coating (SSPC) standards. BLL were used in this study as a quantifiable measurement to assess the level of lead exposure across different trades, abatement methods, and age groups. In this study, the Sen et al. (2002), Sokas et al. (1997), Levin et al. (1998), and Reynolds et al. (1999) articles are compared to BLL across abatement methods and trades from projects in New York in 2018-2020.

The objective of this work is to analyze the lead exposure of lead abatement workers, as measured by BLL. BLL provide a quantifiable level of recent lead exposure (Levin and Goldberg 2000). To achieve this, data from three separate lead abatement projects were analyzed from 2018-2020 in New York. PPE levels were all the same, but crew size, location, abatement methods, and engineering controls varied across the three locations. The operations were located in Manhattan, Yonkers, and Hastings-on-Hudson. Each project had unique work conditions and abatement methods. Entry and exit lead blood levels were obtained and used to determine the extent of the worker’s lead exposure, in accordance with OSHA 1910.1025. The lead abatement PPE used was all the same and was comprised of half face respirators, gloves, and Tyvek coveralls.

Methods

Data from three completed construction projects were used in this analysis. These projects we performed at different locations using different abatement methods and engineering controls to limit workers' exposure to lead. Under OSHA's Lead Standard 1910.1025, blood lead levels shall be monitored when lead abatement work is performed. All three projects occurred between 2018 and 2020 in New York State (New York City and Westchester County). Job tasks are described in Table 1. Personal protective equipment (PPE) requirements comprised of 3M half face respirators with P100 OV cartridges, cut resistant gloves during work, nitrile gloves during prep and cleanup activities, and Tyvek coveralls (with hood and boot covers) and were implemented at all three sites, with one exception for one individual at the pump station where the worker wearing a flame retardant jacket over their Tyvek when operating.

Table 1. Summary of lead removal jobs.

Job	Description	Exposure	Exposure Mitigation
Plasma gun operator	Plasma gun uses extreme heat to burn through the lead coating and through metal.	Lead(II) oxide Lead dust	Lead tape removal operation on the cut area is performed before plasma gun to remove most of the lead paint coating.
Lead tape removal	Lead tape is a polyvinyl tape with strong adhesive used to remove lead paint, often used when the paint coating is visibly chipping. The tape is applied, bonded, and removed.	Lead chips	Performed in the containment area with either mechanical or natural ventilation. While workers were in PPE.
Needle gunning	Needle gunning, also referred to as needle scaling gun, is a power tool with dozens of very fine chisels known as needles that rapidly move chipping away at the lead coated surface.	Lead dust	Mechanical or natural ventilation with PPE. Society for Protective Coatings (SSPC) containments areas with air flow. Needle guns have a shroud that surrounds the needles and must be held firmly

			against the work surface to contain lead paint chips and dust at their source. A HEPA-filtered vacuum and hose connected to the shroud collects the lead dust safely.
Mobilization/ demobilization	Mobilization/demobilization is the process of setting up, cleaning up, and dismantling of the regulated area.	Lead dust	HEPA vacuums are used to clean containment areas.
Abrasive blasting	Abrasive blasting is where workers use a specialized tank with hoses with nozzles that shoot out steel grit at a very high velocity against a steel surface with a lead paint coating.	Lead chips Lead dust	Abrasive blasting uses a specialized shroud that encases the nozzle against the surface. It blasts steel grit against the surface and collects the steel grit and most of the lead paint chips and dust generated. The nozzles are connected to hoses that are connected to a tank, often as truck, with a recyclable feature that cleans and reuses the steel grit. Steel grit recycling significantly reduces dust generation during blasting. Employee exposure to is reduced, which increases productivity from improved visibility and helps maintain a consistent blast profile (Stewart et al. 2021).

The first project selected for analysis was rehabilitation of a subway in the Upper West Side of Manhattan, conducted from February to October, 2018. The lead abatement operations took place in an underground subway station with a 32-person crew. Abatement was performed on lead painted steel columns and beam surfaces via abrasive blasting. Secondary abatement of the entrances, interior stair ceilings, and platform areas was conducted by needle gunning and lead tape removal. Minor abatement was performed on concrete surfaces in control areas via needle gunning. Other workers performed the mobilization and demobilization of the work areas and vacuumed the containment areas at the completion of each shift. Engineering controls for this site included SSPC Class 1A tight enclosure containments and a dust collector negative-pressure exhaust ventilation system to control worker exposures and environmental emissions. Job tasks were classified as Lead Tape Removal, Needle Scale Gunning, Mobilization/Demobilization, Abrasive Blasting, and Vacuuming. All lead abatement jobs followed the same engineering controls due to the indoor nature of the work and containment requirements. All workers wore the same PPE (3M half face respirators with P100 OV cartridges, cut resistant gloves during work, nitrile gloves during prep and cleanup activities, and Tyvek coveralls).

The second project studied in this analysis was a wastewater treatment and pump station plant in Yonkers, conducted from February to March, 2019. Lead abatement took place indoors with a 5-person crew. The crew was instructed to cut and remove several steel pipes that were coated in lead paint with the use of a plasma gun. Tape was used to mark the cut lines and prevent lead paint dust emissions when the plasma gun cut through the steel. Workers were instructed to mobilize and demobilize the work area and vacuum the containment at the end of each shift. SSPC Class 2P containment was used with containment walls surrounding the work area and containment beneath the work area catching the debris. Fans were placed around the containment to create positive pressure to circulate fresh air into the containment. Job tasks were classified as Plasma Gun, Lead Tape Removal, Mobilization/ Demobilization, and Vacuuming. Engineering controls remained the same for all tasks. One member of the crew had a different PPE because he was operating the plasma gun. The PPE change consisted of a flame retardant jacket above his Tyvek and a specialized welding helmet, to provide protection from the heat and light emitted by the plasma gun. All workers otherwise had the same PPE (3M half face respirators with P100 OV cartridges, cut resistant gloves during work, nitrile gloves during prep and cleanup activities, and Tyvek coveralls).

The third project was located in Hastings-On-Hudson from July to September, 2020. The abatement took place outdoors at an overhead bridge with a 9-person crew. The crew was instructed to needle gun the footings of the bridge abutments so that the bridge could be broken into segments to be disposed of. Engineering controls for this included HEPA vacuums and SSPC Class 3P with the aid of polyvinyl tarps encasing the work location. Natural air flow was used as ventilation. Job tasks included Needle Scaling Gun, Mobilization/ Demobilization, and Vacuuming. All lead abatement jobs followed the same engineering controls due to the outdoor nature of the work, and all workers had the same PPE (3M half face respirators with P100 OV cartridges, cut resistant gloves during work, nitrile gloves during prep and cleanup activities, and Tyvek coveralls).

Study Participants

Study participants were selected from the crews performing the lead abatement work. The data gathered consisted of crew size at each project, age range (4 age classifications of 24-33, 34-43, 44-51, and 52-59) for when project occurred, and initial and exit blood lead levels.

These data were obtained from the company's records and daily work schedules. Exit blood lead levels are taken at the completion of abatement and are submitted to evaluate worker exposure for medical clearance. Blood lead levels were obtained by venous blood lead test and tested with the Lead Standard Profile analysis by atomic absorption spectroscopy (AAS). A method recommended by the WHO for environmental exposure and the OSHA Lead Standard for occupational exposure.

Table 2. Job Task Distribution by Project and Age Range

Age	Plasma Gun	Lead Tape Removal	Needle Gun	Mobilization/ Demobilization	Abrasive Blasting	No Abatement	Vacuuming
Manhattan							
24-33	0	0	2	1	1	0	0
34-43	0	1	1.5	3	3	0	0.5
44-51	0	1.5	2.5	4	3	0	2
52-59	0	0.5	5.5	2	1	0	1
Yonkers							
24-33	0.5	0.5	0	0	0	0.5	0.5
34-43	0	0	0	1	0	0.5	0.5
44-51	0	0	0	0	0	0	0
52-59	1	0	0	0	0	0	0
Hastings-on-Hudson							
24-33	0	0	0.5	0	0	0	0.5
34-43	0	0	0	0	0	0	0
44-51	0	0	0.5	1	0	0.5	1
52-59	0	0	3.5	1	0	0	0.5

**Note: 0.5 values represent worker doing 2 tasks.*

<u>Manhattan</u>*: 10 workers conducted abrasive blasting, 4 of those also vacuumed. 15 workers conducted needling gunning, 3 of those also vacuumed and 2 of those also did lead tape removal*

<u>Yonkers</u>: 2 workers did not perform abatement activities and only vacuumed. 1 worker operated the plasma gun and performed lead tape removal.
<u>Hastings-on-Hudson</u>: 1 worker performed no abatement and only vacuumed. 6 workers performed needle gunning and 3 also vacuumed.

The subway project was a 32-person crew and the age ranged from 24-59. There were three workers between the age of 24-33, eight workers between the age 34-43, eleven workers between the age of 44-51, and ten workers between the age of 52-59. There were two workers between the age of 24-33, two workers between the age of 34-43, five between the age of 44-51, and six workers between the age of 52-29 who performed needle scaling. There were five workers who performed the mobilization and demobilization of the work area. There were two workers between the age of 34-43, one worker between the age of 44-51, and two workers between the age of 52-59 that performed mobilization and demobilization of the work area. There were ten workers who performed abrasive blasting. There was one worker between the age of 24-33, three workers between the age of 34-43, four workers between the age of 44-51, and two workers between the age of 52-59. In addition to these tasks, 7 workers vacuumed the lead abatement work area. There was one worker between the age of 34-43, four workers between the age of 44-51, and two workers between the age of 52-59.

The pump station at Yonkers had a 5-person crew and the age ranged between 24-59. Two workers operated the plasma gun. One worker was 24-33 and the other was 52-59. The worker between the age of 24-33 also performed lead tape removal. One worker performed mobilization and demobilization of the work area and the age of the worker was between 34-43. The other two workers did not perform any abatement work and only vacuumed the work area. The workers were between the age of 24-33 and 34-43.

The overhead bridge at Hastings-On-Hudson had a 9-person crew and the age ranged between 24-59. There were six workers who performed needle scaling. There was one worker between the age of 24-33, one worker between the age of 44-51, and four workers between the age of 52-59 who needle gunned. There were two workers who did mobilization and demobilization of the work zone, one worker was between the age of 44-51 and the other worker was between the age of 52-59. There were three of the needle gunners who also vacuumed. There was one worker who was between the age of 24-33, one worker between the age of 44-51, and one worker between the age of 52-59 who needle gunned and vacuumed. There was one worker who did not perform any abatement work and only vacuumed. The worker was between the ages of 44-51.

Data Analysis

Secondary data consisting of age range, blood lead levels, and worker tasks from the different jobsites were input into Microsoft Excel and was compared with data in the Sokas et al.(1996), Reynolds et al. (1999), Sen et al. (2002), and Levin et al. (1998) articles data. The data included Jobsite, Job Task, Mean BLL, and Sample Size. The mean, standard deviation, and confidence interval for blood lead level were then calculated using the data. A forest plot was constructed to illustrate the mean blood lead levels with the confidence intervals from the data gathered from the three construction projects and compared to the data presented in the four articles. The data are separated by article, project, and job task on the project for this study and for the studies in the literature.

IRB and Human Subjects

The IRB application detailed how the information was gathered and de-identified. The goal of the analysis and interprets this data to determine if there are any relationships. Entry blood lead levels are taken and submitted prior to orientation on the jobsite. North Carolina State University exempted the application due to the use of de-identified secondary data.

Results

Blood lead levels were varied across each task and work environment. Job tasks included: No Abatement Activity, Plasma Gun, Lead Tape Removal, Needle Scaling Gun, Mobilization and Demobilization, and Abrasive Blasting. There were a few instances where workers did more than one job task (i.e., lead tape removal and needle scaling gun). Workers who vacuumed the lead work area were also included. Among the three sites, the Manhattan Subway Project had the highest levels and highest change in blood lead levels. Yonkers Pump Station Wastewater Treatment had slightly higher blood lead changes than the Hastings-on-Hudson Bridge Project.

At the Manhattan jobsite, the average entry blood level was 0.5 μg/dL ranging between 0 μg/dL and 3 μg/dL for the entire jobsite. The average exit blood level was 3.8 μg/dL ranging between 1 μg/dL and 21 μg/dL for the entire jobsite. Workers at this jobsite had highest levels compared to the other two jobsites. Specifically, workers who performed blasting had much higher blood lead levels compared to the rest of the workers on this project. This project had the biggest change in blood lead levels and highest blood lead levels across all tasks, compared to the other projects. Those who performed abrasive blasting also had the highest change in blood lead levels compared to all the other job tasks at the different projects. Figures 1-5 below show the change in blood lead level by job task at the Manhattan subway project.

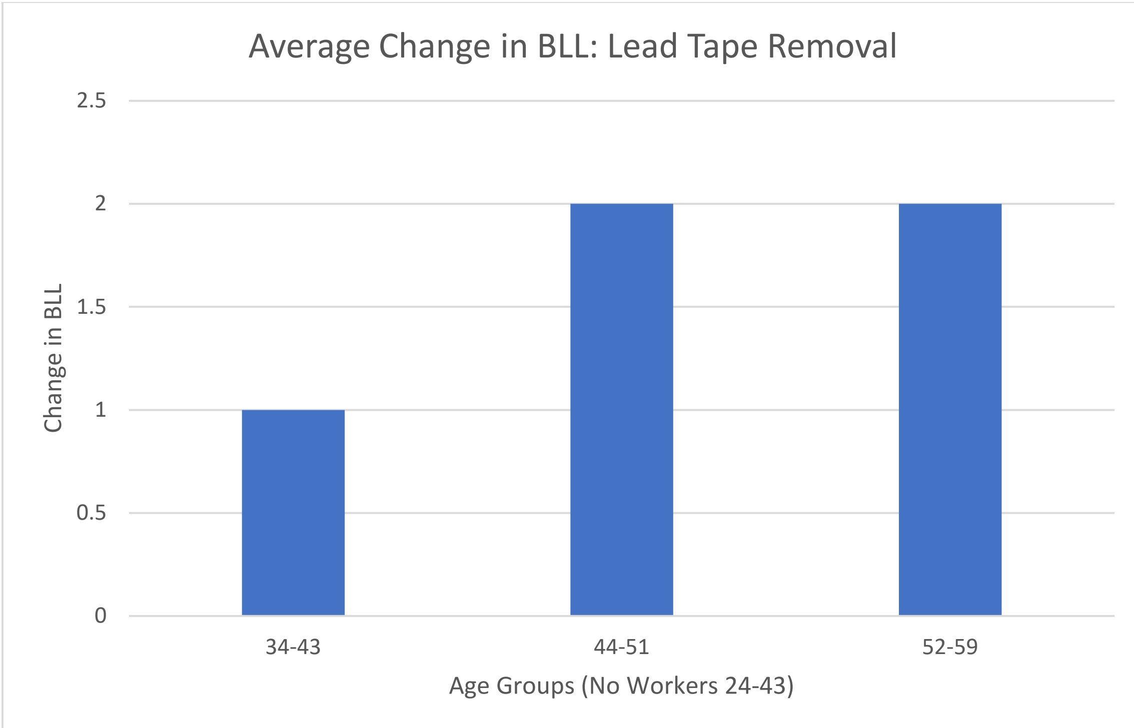

Figure 1. Manhattan subway project lead tape removal change in BLL, by age group.

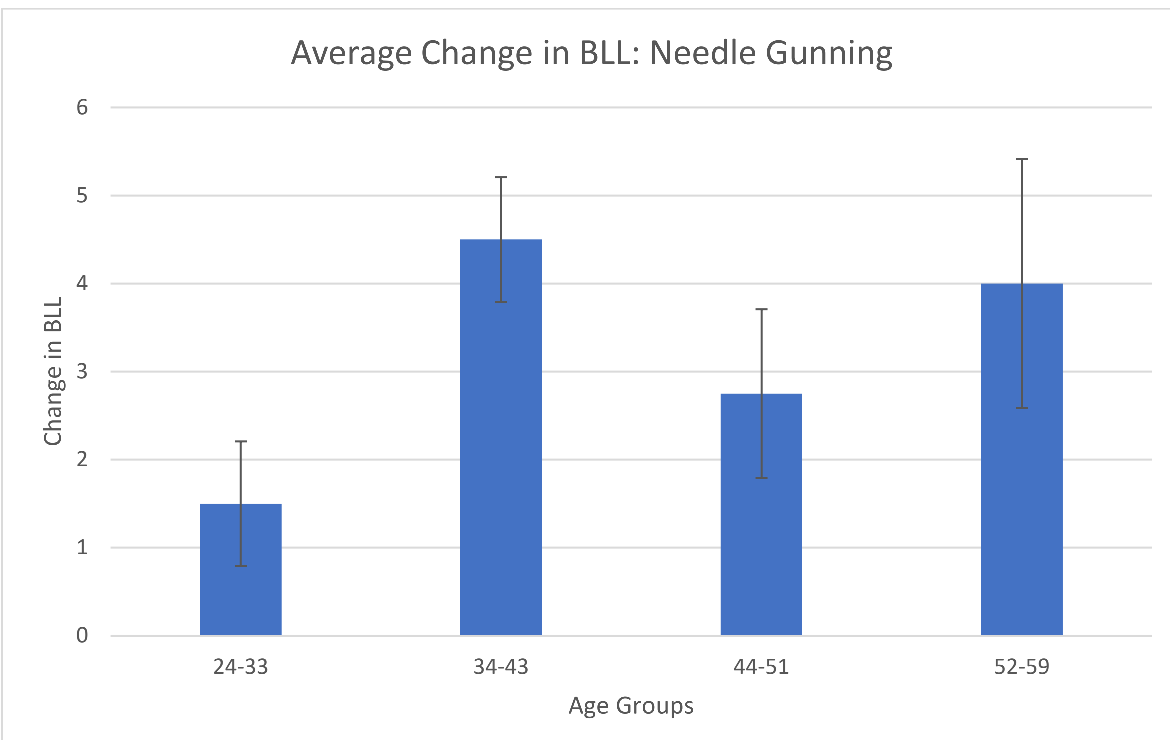

Figure 2. Manhattan Subway Project Needle Gunning Change in BLL vs Age Groups

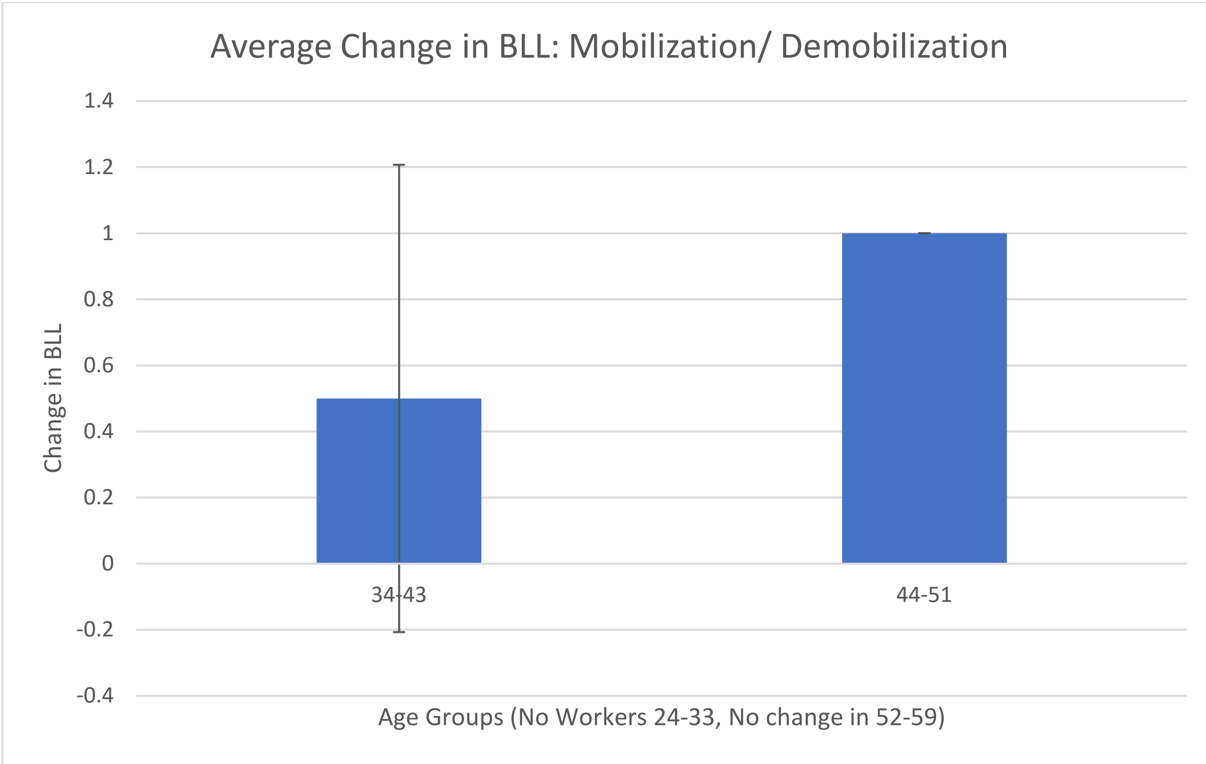

Figure 3. Manhattan Subway Project Mobilization/ Demobilization Change in BLL vs Age Groups

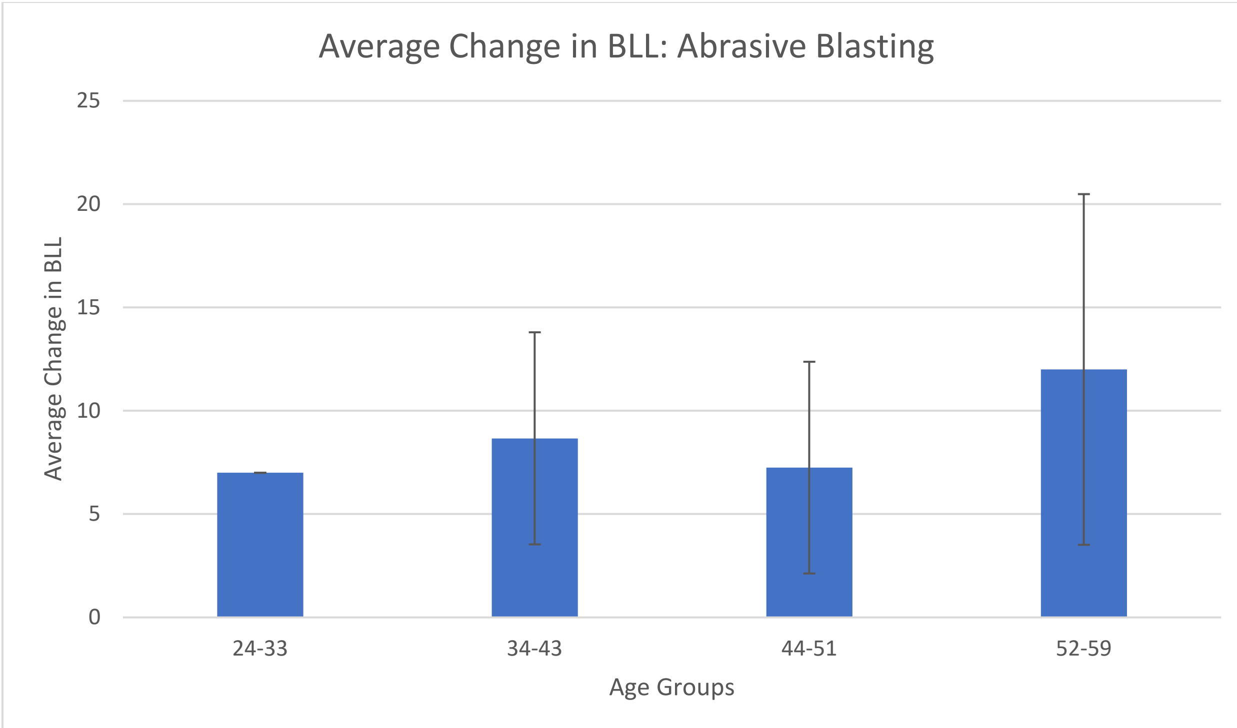

Figure 4. Manhattan Subway Project Abrasive Blasting Change in BLL vs Age Groups

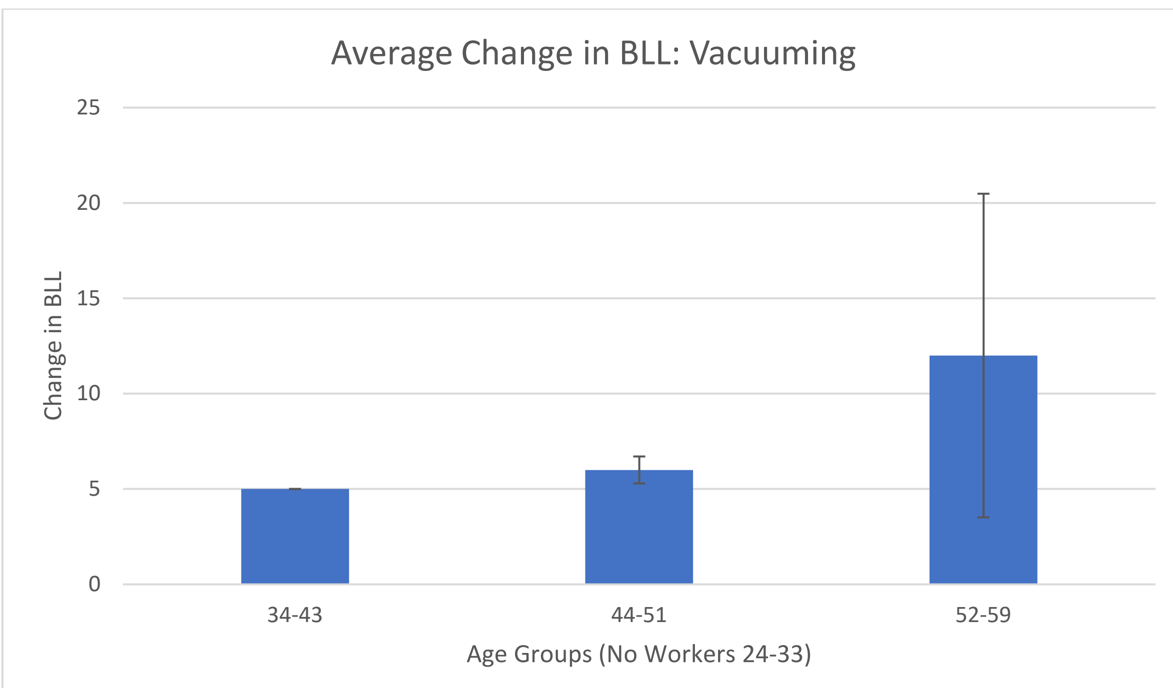

Figure 5. Manhattan Subway Project Vacuuming Change in BLL vs Age Groups

At the Yonkers Pump Station Wastewater Treatment Project, all workers had an entry blood level of 0 µg/dL. The average exit blood lead level was 2 µg/dL and ranged between 1 µg/dL and 3 µg/dL. There was a much smaller crew size on this project. Tasks included plasma gunning, lead tape removal, and mobilization/ demobilization. Vacuuming was also performed. Both the Manhattan Subway Project and Yonkers Pump Station Wastewater Treatment Project occurred in an indoor environment. Workers who performed mobilization/ demobilization had an increase in 1-2 µg/dL. Figure 6 and Figure 7 show the change in blood lead level by job task at the Yonkers Pump Station Wastewater Treatment site.

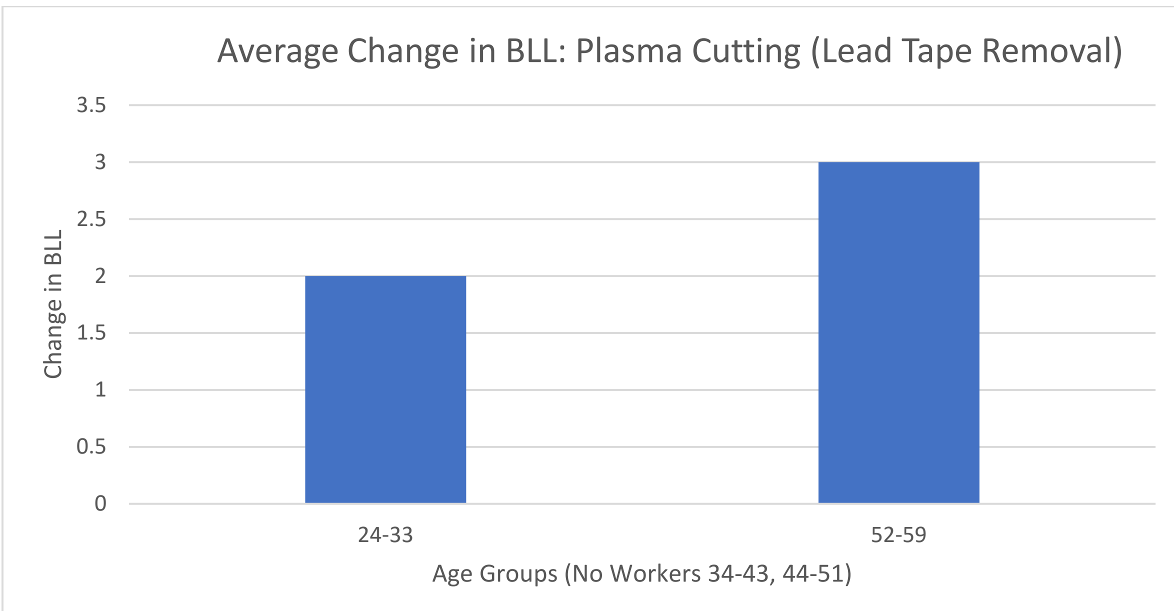

Figure 6. Yonkers Project Pump Station Wastewater Treatment Plasma Cutting with Lead Tape Removal Change in BLL vs Age Groups

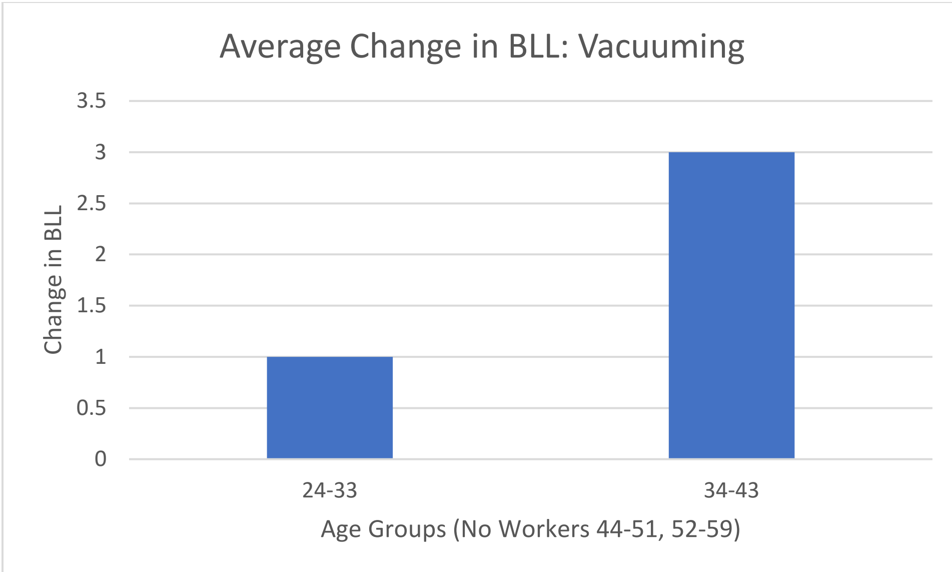

Figure 7. Yonkers Project Pump Station Wastewater Treatment Vacuuming Change in BLL vs Age Groups

Unlike the other projects, the Hastings-On-Hudson Bridge Project was outdoors. Needle scaling and mobilization/demobilization were performed at this jobsite. Vacuuming was also performed. At the Hastings-on-Hudson jobsite, the average entry blood level was 1.6 µg/dL, and the average exit blood lead level was 2.2 µg/dL. This jobsite had the least exposure compared to the other two. The highest change in a worker's blood lead level was 1 µg/dL. There was no change in blood lead levels for those who performed mobilization/ demobilization. Figures 8-11 show the change in blood lead level by job task at the Hastings-On-Hudson Bridge project.

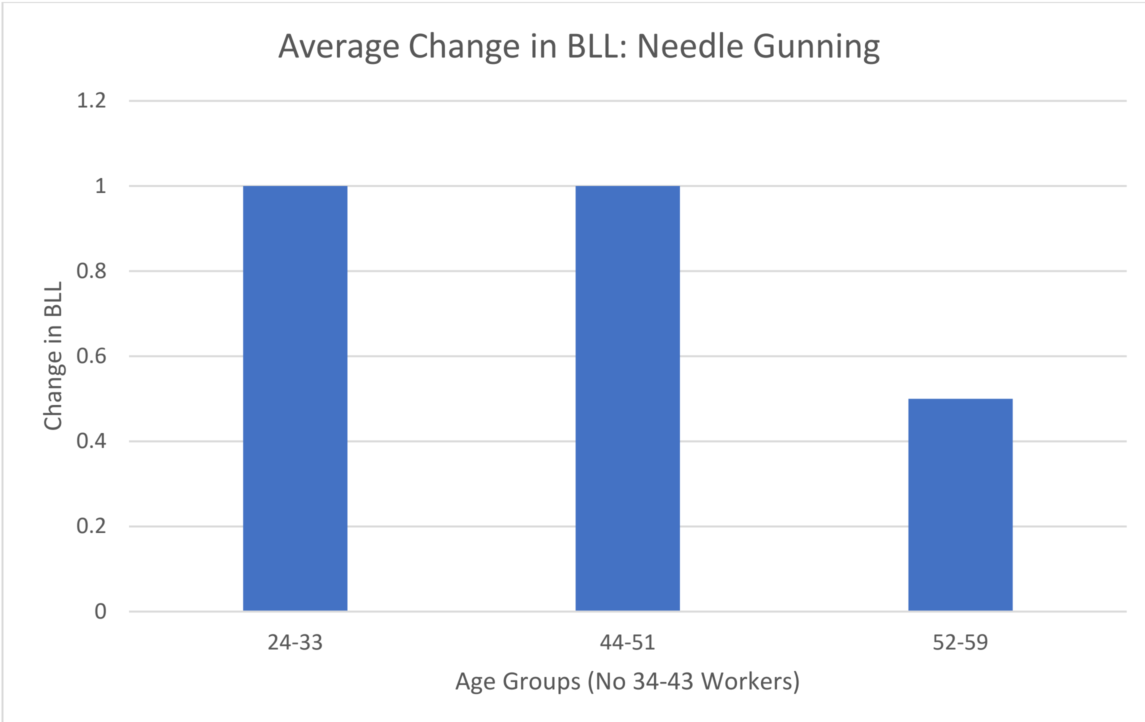

Figure 8. Hastings-On-Hudson Bridge Project Needle Gunning Change in BLL vs Age Groups

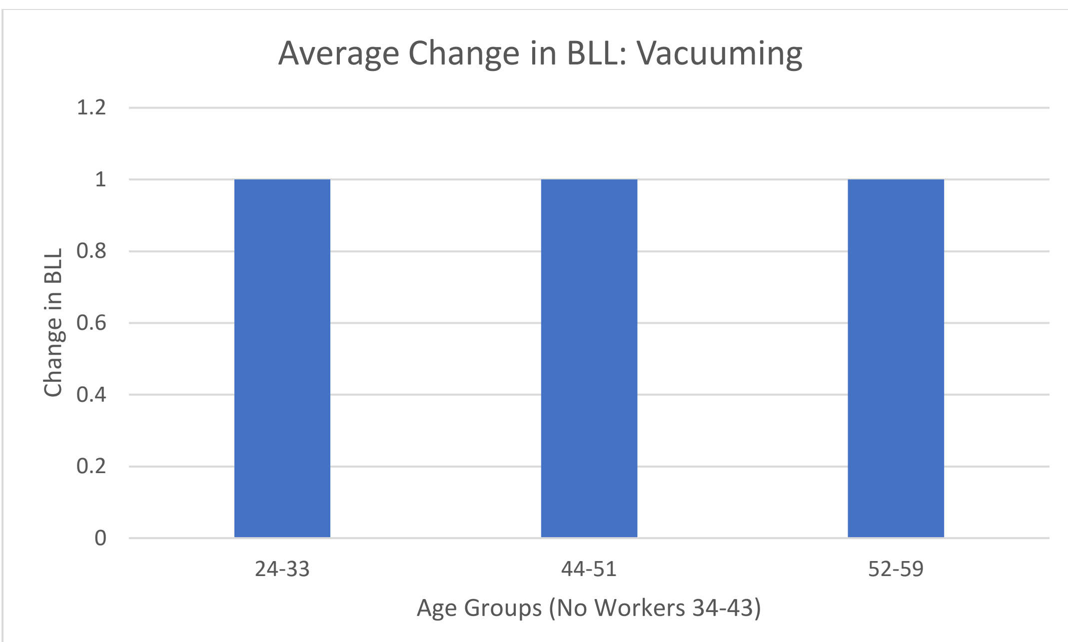

Figure 9. Hastings-On-Hudson Bridge Project Vacuuming Change in BLL vs Age Groups

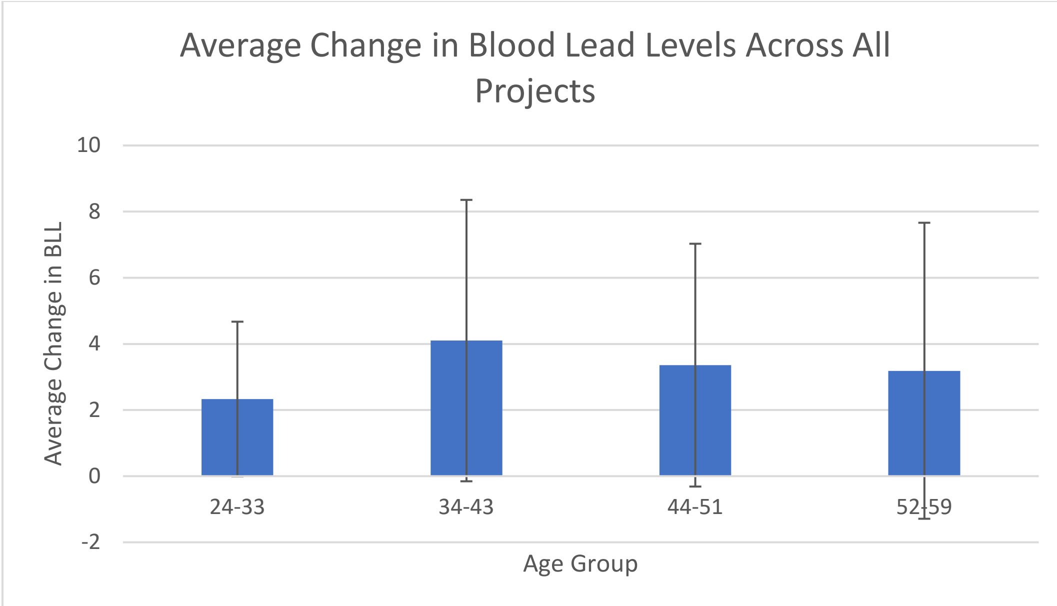

Figure 10. Average Change in Blood Lead Levels Across All Projects

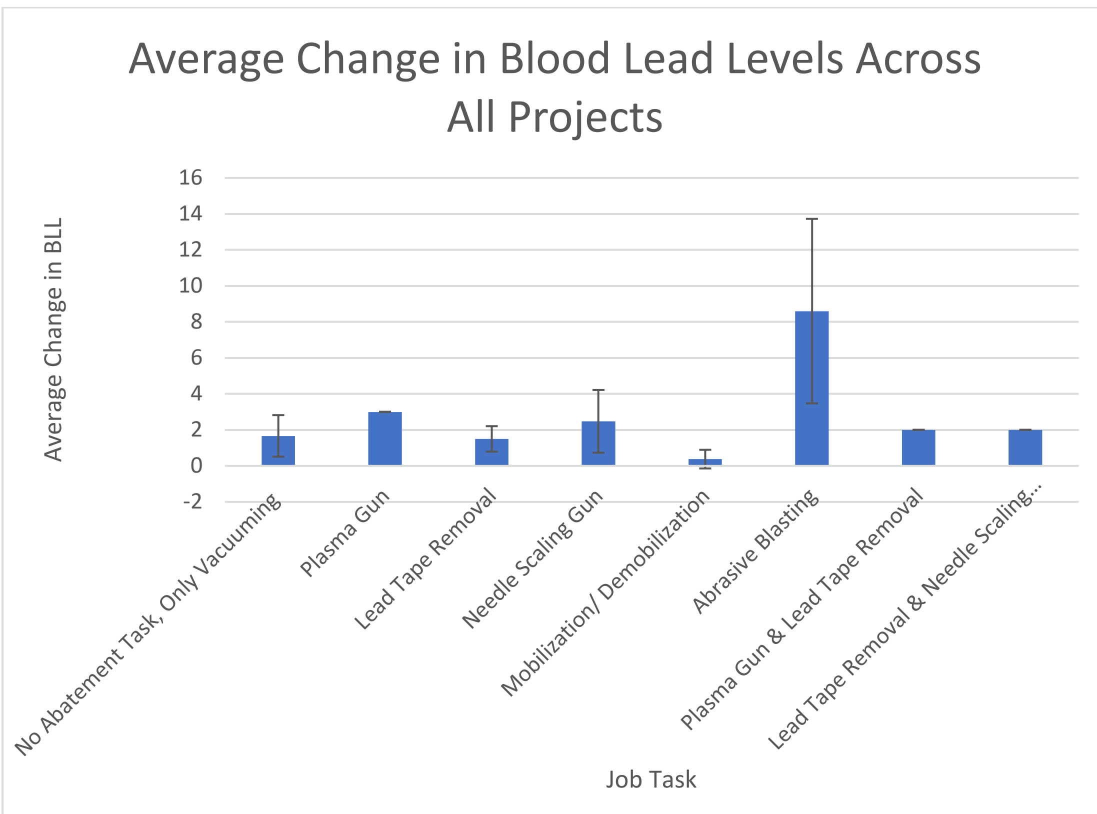

Figure 11. Average Change in BLL By Task Across All Projects and Ages

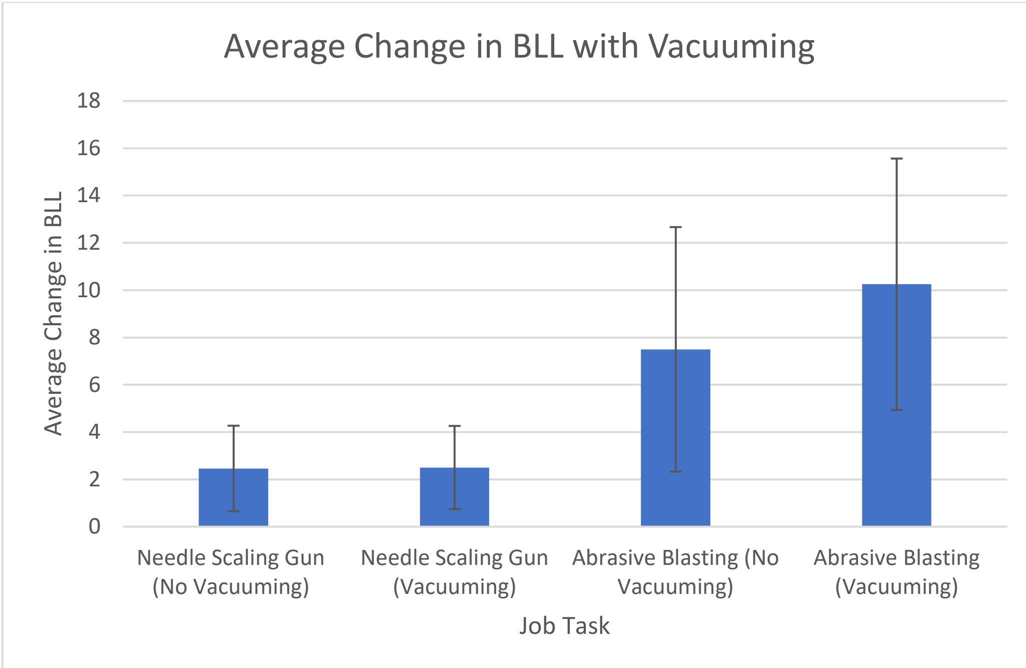

Figure 12. Average Change in BLL with Vacuuming

Author	Jobsite	Job Task	Sample Size
Sokas	N/A (Construction Workers in Maryland)	Demo (ever)	124
		No Demo	140
		Welding/Burning	79
		No Welding/Burning	48
Reynolds	N/A (Construction Workers in Iowa and Illinois)	**All Jobs**	437
		Painters	83
		Plumbers	82
		Laborers	80
		Ironworkers	87
		Electricians	91
		Other	14
Sen	Steel Railway Bridge	Scaffolders	27
Levin	Bridge- NYC	Iron workers-1993	100
		Iron workers-1994	85
PM	Subway-NYC	Lead Tape Removal	4
		Needle Scaling Gun	15
		Mobilization Demobilization	5
		Abrasive Blasting	10
		Vaccumed	7
	Waste Water Pump Station- Westchester NY	Plasma Gun	2
		Lead Tape Removal	1
		Mobilization Demobilization	1
		Vaccumed	2
	Bridge- Westchester NY	Needle Scaling Gun	6
		Mobilization Demobilization	2
		Vaccumed	4

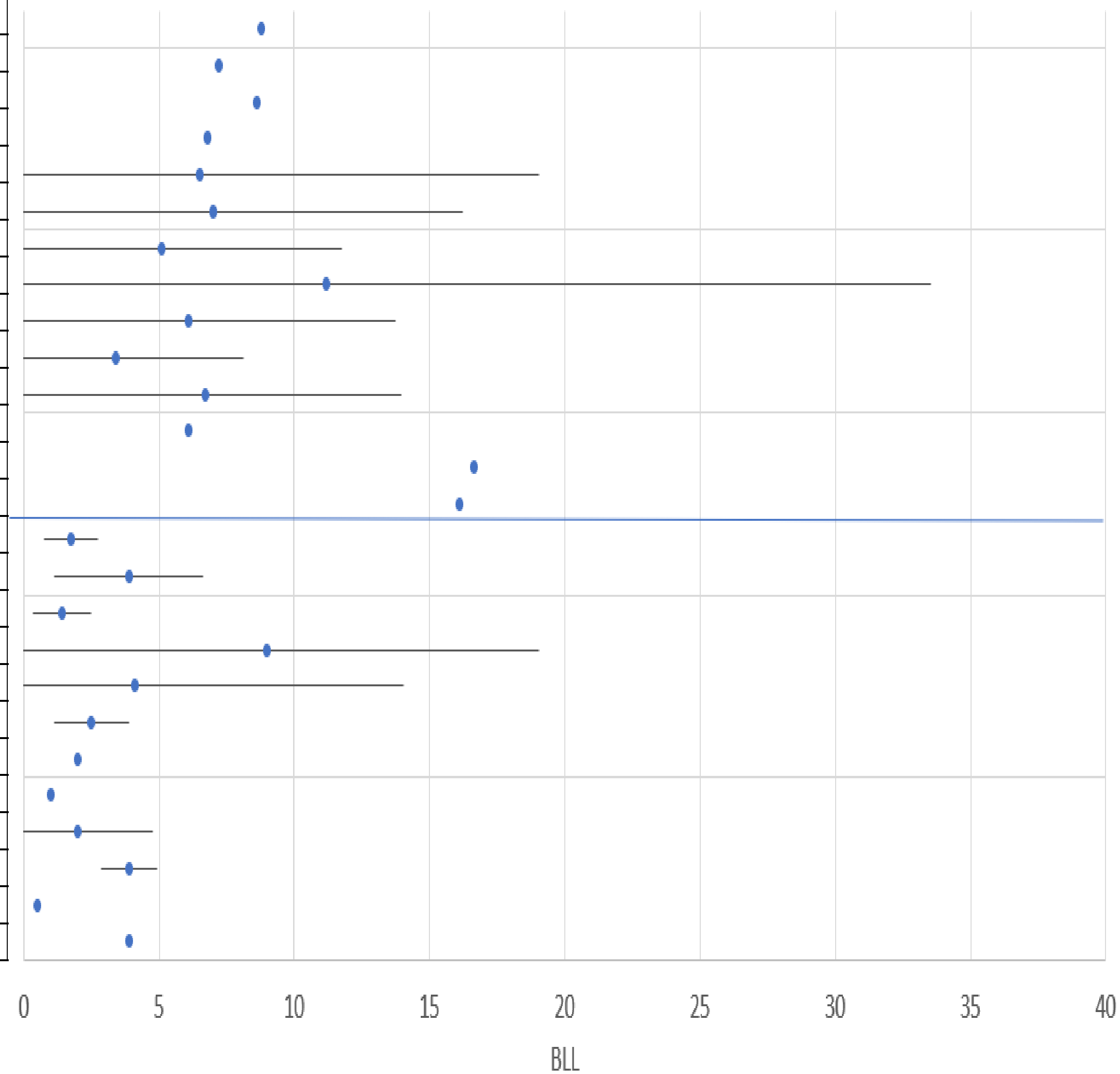

Figure 13. Mean Blood Lead Levels with the Confidence Intervals from the Data Gathered from the Three Construction Projects and Compared to the Data Presented in the Four Articles

Discussion

Data gathered from these three projects were compared to the data in Sokas et al. (1996), Reynolds et al. (1999), Sen et al. (2002), and Levin et al. (1998) (Figure 1). The values below the blue center line in Figure 1 represent the data gathered from the three job sites, and the data above represent the data gathered from Sokas et al. (1996), Reynolds et al. (1999), Sen et al. (2002), and Levin et al. (1998) articles. There are similarities among the four articles by job task having relative similar levels by task. Work environment and conditions varied, however, average blood lead levels by task were relatively similar across all the data gathered.

At the Yonkers Pump Station Wastewater Treatment jobsite, where plasma cutting was used, there was an increase of blood lead levels of 2-3 μg/dL compared to those who did not perform this task. The slight increase in blood lead levels at the Yonkers Pump Station Wastewater Treatment compared to the abatement done in Sokas et al. (1996) could be attributed to better technology in the burning equipment, developments of PPE, and stricter enforcement of engineering controls under OSHA. Sokas et al. (1996) showed an increase in the blood lead levels of union construction workers who performed abatement work (demolition, burning) and compared to workers who did not perform the abatement work. Workers who had performed abatement work had increased blood lead levels compared who did not perform these activities. The average of blood lead level of a worker who ever burned or welded was 8.6 μg/dL while those who did not burn or weld had a blood lead level of 6.8 μg/dL.

At the Manhattan Subway project, the workers who performed the abrasive blasting had the highest change in blood lead levels at an average of 9 μg/dL. The development of recyclable steel grit has lowered workers' exposures. However, workers who performed abrasive blasting on the Manhattan Subway project still had the highest blood lead levels and the highest variability in the change of blood lead levels. The dramatic increases in some of the blood lead levels could have been caused by improper use of the shroud that allows the grit to be recycled and lowers the amount of lead released. Improper use of PPE could also be a factor if the half face respirator did not have a proper seal on the workers' faces or the cartridges were not replaced. Respirator selection could have been changed from a half face respirator to a full face respirator to allow for a higher assigned protection factor. Reynolds et al. (1999) analyzed blood lead levels across all different trades on various projects in Iowa and Illinois. Ironworkers had the highest level of blood lead levels across all trades in this study. Average blood lead level was 11 μg/dL and the job tasks included welding, sand blasting, rivet busting, burning lead-painted structures, and demolition work.

Sen et al. (2002) studied the effect of laborers who do not perform lead abatement but work in the regulated area setting up scaffolds and performing cleanup job tasks. The average blood lead level was 6 μg/dL in Sen et al. (2002). In all three jobsites, workers performed mobilization/demobilization and vacuuming where the average blood lead level was 1 μg/dL and 4 μg/dL. Sen et al. (2002) calls out several potential missteps in the mobilization/demobilization process. One of which is the failure to implement "clean" vs "dirty" area policies. When a worker is in the clean area, it is deemed lead contamination free, as opposed to the dirty area where it is presumed that there is lead contamination. Workers are able to eat and drink in the clean area, which if contaminated can cause a sharp increase in blood lead levels. Personal protective equipment and engineering controls are supposed to be followed in the "dirty" area. Another misstep was that the reusable items were not cleaned prior to the demobilization phase. There were also several issues with the personal protective equipment in Sen et al. (2002) including no Tyveks, lack of respiratory protection, and lack of towelettes.

Levin et al. (1998) used data gathered from iron workers employed in the renovation of a large, lead-painted, steel bridge in New York City in 1993-1994. Iron workers were the focus of the study and had a blood lead level of over 16 μg/dL each year. Iron workers in this study performed work with pneumatic tools such as blasting and needle scaling guns. At the Manhattan Subway Project, the workers who performed the abrasive blasting had the highest change in blood lead levels at an average of 9 μg/dL. Needle scaling at the Manhattan Subway Project and the Bridge in Hastings-on-Hudson all had an average of 4 μg/dL. Levin et al. (1998) reported exceedingly high blood lead levels, some workers were over 30 μg/dL. The main difference between Levin et al. (1998) and the Hastings-On-Hudson Bridge project is the astronomically higher entry baseline blood lead levels in Levin et al. (1998) with workers having entry blood lead levels over 16 μg/dL. This is attributed to the lack of OSHA enforcement and standards during this job in 1993-1994. Levin et al. (1998) and the Hastings-On-Hudson Bridge project both had the same task of needle gunning an outdoor bridge.

There were both strengths and limitations of the data gathered for the analysis. The same level of PPE was used across all three sites. Site conditions varied from indoor, outdoor, and below-ground. Data was gathered from five different abatement methods used as well as vacuuming after the abatement task. There we different abatement surfaces were used at all the different projects including steel beams and concrete. However, there were a few instances of workers working multiple job tasks, which hinders deduction of what could have caused an increased blood lead level.

The biggest limitation in the reported data is the crew size, especially at the Yonkers Pump Station Wastewater Treatment project. The sample size was relatively small compared to the Sokas et al. (1996), Reynolds et al. (1999), Sen et al. (2002), and Levin et al. (1998) articles.

While the PPE remained the same, there were also different SSPC containments used at each project, which could have influenced workers exposure with changes in exhaust and emissions control. Manhattan Subway project used a SSPC Class 1A tight enclosure containments and a dust collector negative-pressure exhaust ventilation system to control worker exposures. Yonkers wastewater treatment pump station used SSPC Class 2P containment was used with containment walls surrounding the work area and containment beneath the work area catching the debris. Hastings-on-Hudson bridge project included natural ventilation and SSPC Class 3P with the aid of polyvinyl tarps encasing the work location. There were limitations in the approach analyzing the data as well. Only focusing on age range and change in blood lead levels with respect to job task and environment. This analysis does not consider body size nor preexisting conditions that would cause excessive levels. For example, someone taller with more bone mass would be at risk for having more lead in their blood. Smokers also may have increased in blood lead levels do to cigarettes containing lead. The analysis also does not consider job task duration and potential overtime shifts.

Conclusions

Lead paint abatement is a common practice in the construction industry and limiting the workers exposure to airborne particulate lead is a top priority, because unmonitored and prolonged exposure to airborne particulate lead can result in acute or chronic illnesses. Based on findings presented in Sen et al. (2002), Sokas et al. (1997), Levin et al. (1998), and Reynolds et al. (1999) and the results from the three abatements in 2018-2020 in New York (Manhattan Subway Project, Yonkers Pump Station Wastewater Treatment Project, and Hastings-On-Hudson Bridge Project) workers' risk of exposure exists regardless of abatement method. However, certain job trades, such as iron workers as shown in Reynolds et al. (1999), can have higher BLL and certain abatement methods, such as abrasive blasting as shown in the Manhattan Subway Project, will generate more airborne particulate lead, potentially resulting in an increased exposure and a higher change in BLL. Workplace exposure to airborne particulate lead has improved over time due to better abatement technology, more knowledge about preexisting health conditions, and more stringent regulations, especially under OSHA §1910.1025. Based on the analysis of literature and the additional projects, the abatement methods that are most effective in reducing lead exposure are mobilization/demobilization, needle gunning, plasma gunning, and lead tape removal. Abrasive blasting and vacuuming were the least effective in reducing workers exposure to lead.

Using OSHA's hierarchy of controls of elimination/ substitution, engineering controls, administrative controls, and PPE will mitigate the workers' exposure. Following OSHA §1910.1025 Appendix C and performing medical surveillance when performing abatement is crucial to assessing a workers exposure. Ensuring workers have entry and exit BLL measurements allows for proper identification of risks for adverse health outcomes. Quantifying workers' change in BLL also allows for employers to make necessary changes to abatement practices to improve the workers' protection.

The variations of increased blood lead levels were better understood after this analysis. Projects with different abatement methods, engineering controls, impact of vacuuming, and project environments all contribute to the workers' potential exposures and resulted in varied BLL. Certain abatement methods such as needle gunning, plasma cutting, and mobilization/ demobilization were very effective, and workers on these methods had minimal increases in BLL. Abrasive blasting and vacuuming produced the largest increase in BLL.

For future projects, in addition to following OSHA §1910.1025 and SSPC Class standards, there should be considerations for implementing administrative controls such as shift rotation to limit the time each workers are exposed to the airborne particulate lead. Increasing the level of PPE from half face respirators to full face respirators or even Personal Air Purifying Respirators would better protect the workers as a last line of defense. Moreover, pre-existing conditions such as heart damage, kidney damage, older workers, smokers, or high entry BLL's may all increase risk of higher change in BLL's. The additional risks for with workers having pre-existing medical conditions should be considered in job assignments for abatement projects.

REFERENCES

Abbas, M.V. et al. Skin and Surface Lead Contamination, Hygiene Programs, and Work Practices of Bridge Surface Preparation and Painting Contractors, Journal of Occupational and Environmental Hygiene. Volume 6 Issue 2 (2008), Pages 131-142, DOI: 10.1080/15459620802656636 https://www-tandfonlinecom.prox.lib.ncsu.edu/doi/full/10.1080/15459620802656636?scroll=top&needAccess=true

Guth, K. et al. Assessment of lead exposure controls on bridge painting projects using worker blood lead levels. Regulatory Toxicology and Pharmacology, Volume 115. 2020. 104698. ISSN 0273-2300, https://www.sciencedirect.com/science/article/pii/S0273230020301240

Hipkins, K.L. et al. Medical Surveillance of the Lead Exposed Worker: Current Guideline AAOHN Journal; Thorofare Vol. 46, Iss. 7, (Jul 1998): 330-9. https://www-proquest-com.prox.lib.ncsu.edu/docview/1012767649?pq-origsite=summon

Levin SM and Goldberg M. Clinical evaluation and management of lead-exposed construction workers. American Journal of Industrial Medicine. 2000. Jan;37(1):23-43. doi: 10.1002/(sici)1097-0274(200001)37:1<23::aid-ajim4>3.0.co;2-u. PMID: 10573595 https://pubmed.ncbi.nlm.nih.gov/10573595/

Levin SM. et al. The effect of the OSHA lead exposure in construction standard on blood lead levels among iron workers employed in bridge rehabilitation. American Journal of Industrial Health. Volume31, Issue3. December 1998. Pages 303-309. https://doi-org.prox.lib.ncsu.edu/10.1002/(SICI)1097-0274(199703)31:3<303::AID-AJIM6>3.0.CO;2-Y

Local Law 66. §27-2056.1 ET SEQ. New York Lead Paint Standard. https://www1.nyc.gov

OSHA 1910.1025 Appendix C Medical Surveillance Guidelines https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1025AppC

OSHA 1910.1025 Lead Standard. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1025

Reames, G.J. et al. 2001. “Task-Specific Lead Exposure During Residential Lead Hazard Reduction Projects.” Applied Occupational & Environmental Hygiene. Volume 16, Issue 6. Pages 671–78. doi:10.1080/104732201750175889.

Reynolds et al. Prevalence of elevated blood leads and exposure to lead in construction trades in Iowa and Illinois. American Journal of Industrial Health. Volume 36, Issue 2. July 1998. Pages 307-316.

Sen, D et al. Lead exposure in scaffolders during refurbishment construction activity—an observational study, Occupational Medicine, Volume 52, Issue 1, 1 February 2002, Pages 49–54, https://doi.org/10.1093/occmed/52.1.49

Sokas, R.K. et al. Lead levels in Maryland construction workers. American Journal of Industrial Health. Volume31, Issue2. December 1998 Pages 188-194. https://doi-org.prox.lib.ncsu.edu/10.1002/(SICI)1097-0274(199702)31:2<188::AID-AJIM8>3.0.CO;2-W

Stewart, M. et al. The Benefits of Steel Grit Blasting and Recycling. ARS Recycling Systems, LLC. 2021. Pages 1-8.