ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE

SCHOOL OF PUBLIC HEALTH

ASSESSMENT OF OCCUPATIONAL EXPOSURE TO LEAD AND ASSOCIATED FACTORS AMONG WORKERS IN CITY BUS GARAGE IN ADDIS ABABA, ETHIOPIA: A COMPARATIVE CROSS-SECTIONAL STUDY

BY

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Abstract

Background: One of the most unusable chemical exposures that occurred in automotive garage areas was lead. Occupational exposure of garage workers to lead dust commonly poses acute and chronic health risks that can be prevented. In Ethiopia, there have been limited studies on lead exposure among garage workers. Moreover, it overemphasized that workers are more exposed than non-garage workers to lead exposure

Objectives: To assess the occupational blood lead levels and associated factors among the Anbessa City Bus Service Enterprise garage workers in Addis Ababa, Ethiopia.

Methods: A comparative cross-sectional design was used to examine lead levels in 36 garage workers and 34 office workers. A stratified random sampling method was used to identify the study subjects. specimens of blood and associated factors were collected by trained medical laboratory experts. A recent MP-AES device was used to measure lead exposure in blood. Excel and SPSS Version 26 were used for data management and analysis. Linear regression tests were used to investigate associated factors on blood lead levels in the exposed groups, while an independent t-test was used to compare BLLs between the exposed and unexposed groups.

Results: The mean age of exposed groups was 39.0 ±7.5 years, whereas unexposed groups were 37.9 ±6.1 years. Majority of the garage workers, 26 (72.2%), did not know how they were exposed to lead, and 17 (47.2%) of the workers did not wear any personal protective equipment during work activities. The mean BLL (29.7±12.2) µg/dl of exposed groups was statistically significant as compared to the mean BLL (14.8±9.9) g/dl of unexposed groups. Occupational job positions of exposed groups did not statistically significant from one another. Of the exposed groups, 8 (22.2%) had high BLL than the WHO and OSHA recommended limits (40 µg/dl). The main significant factors that affecting blood lead levels were extra daily working hours (β =3.8 µg/dl; $p<0.01$) and long work years (β =0.8 µg/dl; $p<0.03$)

Conclusions: The overall garage workers had high mean blood lead levels as compared to the office workers. Hence, it is recommended that the garage management should apply good exposure prevention mechanisms and should give OSH trainings to employees.

Key words: Blood lead levels, exposure factors, garage workers, Ethiopia

Acronym/ Abbreviations

AAS	Atomic Absorption Spectrophotometry
AAU	Addis Ababa University
ACBSE	Anbessa City Bus Service Enterprise
BDL	Below Detection Limit
BLL	Blood Lead Level
CBRN	Chemical, Biological and Radio-Nuclear
DALYs	Disability-Adjusted Life Years
EPHI	Ethiopian Public Health Institute
EFDA	Ethiopian Food and Drug Authority
FAAS	Flame Atomic Absorption Spectrometry
GFAAS	Graphite Furness Atomic Absorption Spectrometer
IC-PMS	Inductively Coupled Plasma Mass Spectroscopy
IHME	Institute for Health Metrics and Evaluation
ILO	International Labour Organization
MOH	Ministry of Health
MOLS	Ministry of Labour and Skill
MP-AES	Microwave Plasma Atomic Emission Spectroscopy
NIOSH	National Institute of Occupational Safety and Health
NGO	Non-governmental Organization
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
Pb	Lead
PPE	Personal Protective Equipment
SPSS	Statistical Product and Service Solution
UN	United Nations
WHO	World Health Organization

1. Introduction

1.1. Background

Heavy metals are hazardous and toxic trace elements that can affect human health and the environment. However, some heavy metals play essential roles for humans in biological activities by facilitating the oxidation-reduction reaction process. The human body is exposed to heavy metals by inhalation from the environment, ingestion during the consumption of food and water, and skin-dermal contact (1). Worldwide, people are occupationally exposed to chemical exposure through various pathways, including inhalation, ingestion, and skin contact, but the most intensive pathways to chemical exposure are through inhalation and ingestion (2).

Due to its accessibility in the food chain, environment, air, and water, lead is one of the most dangerous and hazardous heavy metals for the workplace and has substantial negative effects (3). Automotive technicians and mechanics, painters and battery manufacturers, municipal waste collectors, and others are usually exposed to lead and are vulnerable to acute and chronic health risks in their day-to-day activities.

Lead (Pb) is a biologically non-essential metal that is found in soil, water, and air and is toxic to humans, animals, and the environment (3). As a result, workers' lack of knowledge about lead exposure, lack of awareness, inability to use personal protective equipment and safety materials, and spending more time at work, particularly in automotive and bus garages, municipal waste incineration sites and battery manufacturing sites, are the primary determinants of lead exposure. Many studies' clinical findings revealed that lead concentrations in blood, urine, nails, and hair were the main primary biomarkers used to investigate lead toxicity in garage workers (4-7).

In Addis Ababa, Ethiopia, there is only one big Anbessa city bus service enterprise that provides transport services in and around the city of Addis Ababa. Under it, there are four bus garage sites at Yeka (Gerji), Gullele (Shegole), Nefas Silk (Jemo-2), and Kality (Kality) Sub-Cities. Hence, this study was conducted to assess the blood lead concentration and its associated factors among the Anbessa city bus service enterprise garage workers in Addis Ababa, Ethiopia.

1.2. Statement of the Problem

Occupational exposure to heavy metals has become a major public health concern around the world. Lead is among the heavy metals commonly observed as an occupational hazard in garage sites that work on car paint, battery filling and repair, and vehicle and bus maintenance. Hence, garage workers are more exposed to lead than non-garage workers (2).

There is currently no known safe blood lead concentration in auto electricians, mechanics, or battery workers, particularly in developing countries. If the exposure of blood lead level in workers greater than from the WHO recommendation limit (40µg/dl),It may be linked to lower IQ, behavioral difficulties, and learning problems, (8, 9). Lead exposure is the result of a disorder of the central nervous system, failure of the kidney, memory retardation, and intestinal and lung cancer. The level of lead in the blood is the most widely used to measure occupationally exposed workers' lead exposure. In 2019, the Institute for Health Metrics and Evaluation (IHME) reported lead exposure caused 900,000 deaths and 21.7 million years of lost healthy life (also known as DALYs) due to its long-term impact on health (10, 11).

There are so many garage workers in Addis Ababa, Ethiopia. However, it is observed that the garage workers don't use personal protective equipment and safety measures while they are working. The probability of getting exposed to lead is high when compared to the general population (12). However, the blood or urine lead concentration of the Anbessa City Bus Service Enterprise garage workers has not been studied previously, though some studies were conducted at Jimma and Harer Town only on automotive garage workers (3). the study conducted at Jimma Town in 2012 showed that there was a difference between the mean level of lead concentration on spray painting in automotive garages and that of non-garage workers. However, the study did not divide garage workers into groups of mechanics, painters, and electricians, and it did not demonstrate the associations between parameters like hand hygiene habits and the use of personal protective equipment (PPE). A similar study was also conducted at Harer in 2019; however, the study was measured blood pressure and hematological parameters of the garage workers which did not indicate the level of exposure (2).

Thus, the purpose of this study is to evaluate the extent of lead exposure at work among garage workers in Addis Ababa, Ethiopia, along with its contributing factors

1.3. Rationales of the Study

In recent decades, different manufacturing industries, like automotive garage sites and construction sites, have expanded and used lead for different purposes. Studies around the world showed that some workers who are engaged in garage work checked their blood lead levels on a regular basis. However, in our country, Ethiopia, garage sites, most garage workers did not test their blood lead levels. It is also observed that the garage workers don't use any PPE or safety measures while they are working. It is assessed that few studies were carried out on lead exposure among garage workers in Addis Ababa, even though there are so many garage sites. Lead is one of the most serious occupational hazards of heavy metals, with multiple health effects among garage workers (13). Hence, this study investigated the exposure to lead levels in blood among garage workers in Addis Ababa by comparing them to non-garage workers.

Significances of the Study

The final findings of the study will be presented to the Anbessa City Bus Service Enterprise (ACBSE) to show how many workers are exposed to lead exposure. The study will serve as scientific evidence to enterprise. The research will be also helping institutions, especially the Ministry of Social and Labor Affairs (MOSLA) and Ministry of Health (MOH) to set standards and safety measures for garage workers by establishing standard criteria to minimize lead exposure. Finally, the study may be used as a reference for academic purposes and further investigation of the effects of lead exposure. Based on these findings, researchers will also use them as input to assess and investigate lead toxicity by adding other heavy metal exposures that are released from garages.

2. Literature Review

2.1. Lead exposure

Exposure of heavy metals such as lead, chromium, arsenic, and cadmium pose significant public health concerns around the world (14); hence, millions of workers are exposed to toxic metals, especially lead exposure at garage sites. The mean blood level of lead (Pd) in the exposed group (5.2 μg/dl) was significantly higher (P<0.0001) when compared with the mean level of the unexposed group (1.03 μg/dl) at a wastewater plant in Iraq.

Lead is a typically unnecessary and harmful material that builds up in the environment and the human body and has major negative effects on both (9). The health effects of this toxic substance for a long time, several organs in the human body, including the central nervous system, kidney, liver, hematopoietic system, reproductive system, and endocrine system will be damaged (13). The toxicity of lead especially affects children's health by damaging the brain and nerve system, causing hearing and speech problems, and slowing growth and development, with major risk factors including nutrition, particularly deficiencies of essential metals like calcium, iron, and zinc, and housing and socioeconomic status (15). The exposures of children at low levels may show decreased attention, hyperactivity, mental inability, and diffusion of vision. The five-year cohort study in Silesia, Poland, on lead exposure and associated factors shows that the overall blood lead level was 6.3 mg/dL (ranging from 0.6 to 48 mg/dL) and about 13% of children had 10 mg/dL blood lead concentration, but the proportion of children in the study cities was significantly different, with the highest at 16% and the lowest at 7.5% (P<0.0.01) BLL (16). As a result, children are more sensitive and vulnerable to lead exposure than adults because they usually spend more time in waste areas and dusty places and put things into their mouths without washing their hands. The greatest health risk to lead smelter employees, battery manufacturers, recyclers, construction workers, and radiator repairers is inorganic lead (17).

Each year, the United Nations (UN) estimates that about 10 million occupational diseases and 160 million new work-related diseases occur worldwide, but the severity and frequency are greatest in developing countries due to chemical exposure, manual work, noise, low attention and knowledge, and low inspection by the International Labour Organization (18). symptoms associated with lead exposure might be severe, moderate, or mild. However, muscle and joint

discomfort, headaches, fever, appetite loss, and insomnia are some of the typical clinical indications of lead exposure in workers. A study shows that in Enugu Metropolis, Nigeria, numbness and fatigue on the roadside were associated with BLLs of ≥ 10μg/dL, while weakness and fatigue were associated with BLLs of ≥ 10 μg/dL among organized panel beaters (19, 20).

2.2. Factors Affecting Lead Exposure

Workers who maintain, dispose of garbage, recycle, or repair batteries may be exposed to lead at work due to improper use of personal protective equipment (PPE), a lack of knowledge, the length of hours to do the work, and lack of hygiene precautions(21). Awareness of workers to lead exposure in the workplace is the main determinant of occupational health and safety conditions to reduce lead exposure risks. Low-wage workers' half-lives are typically spent in car welding and soldering workshops, manufacturing, construction, painting, and other activities (17, 21-23). Therefore, a safe and clean environment is an important preventive mechanism to prevent the occurrence of workplace accidents and chemical exposure transmission through ingestion, inhalation, and skin contact, as chemicals without proper labeling may cause accidents. As a result, regular cleaning and hygiene practices in the workplace help to ensure and create a safe environment by reducing occupational disease transmission (24).

According to estimates, 20–50% of workers in industrialized nations and 5–10% of workers in poor nations, respectively, have access to effective occupational health treatments. However, more people die each year from occupational diseases and injuries than from malaria, with nearly 2 million deaths worldwide each year(18). Hence, by improving and setting up occupational safety and health protocols, workers protect themselves from health hazards associated with physical hazards, chemical hazards, and biological agents.

In garage workshops around the world, especially in developing countries, personal protective equipment (PPE), hygiene and sanitation practices, clinics, ventilation, and good housekeeping facilities are necessary and available to establish safe work conditions and reduce exposure to metal dust, fumes, and other particulate matter (17, 21, 23). Ventilation keeps the air free of contaminants that could enter the body through inhalation. Despite a small increase in public understanding of the negative health effects of chemical exposure in general, knowledge of lead exposure among employers and employees still leaves gaps in how to properly protect

themselves from the acute and long-term effects of toxic metals in their day-to-day work activities A comparative cross-sectional study was done in organized and roadside garages in Nigeria to assess the BLL and awareness of respondents about lead exposure (25).

2.3. Common Sources and Routes of Lead Exposure

Today, most people in developing countries, especially municipal garbage collectors, garage, construction, and mining workers (including Ethiopia), are exposed to lead exposure through inhalation, skin absorption, and ingestion, but the most common routes of human exposure to lead are through inhalation and ingestion via the gastrointestinal and respiratory tracts (26). Once inhaled with heavy metals, damage can occur. Studies show that about 40 to 50% of small particulates of lead are absorbed and retained in the lung. The main sources of lead hazards can be found in food, water, soil, gasoline, e-waste, air, and occupational vehicle repair from inside and outside of living homes (27). In the Iraqi study on occupational lead exposure in electrical solders, the average occupational exposure of workers with lead in the air was 0.09 ± 0.01 mg/m3 (ranging 0.00 to 0.15 mg/m3), and lead levels in the blood were on average 10.59±3.25 g/dL (ranging from 6.60 to 19.20 µg/dL) which is higher than the recommended threshold (0.05 mg/m3) limit (28).Young children are usually vulnerable and affected by lead exposure because they can absorb about 40–50% of an oral dose of water-soluble lead compared to 3–10% of adults from the given sources (16, 29, 30). The reduction in lead exposure emissions from sources is correlated with the reduction in lead exposure concentrations; however, the increased emissions of lead exposure can have an impact on several organ systems.

2.4. Blood Lead Level and its Standard Criteria

The standard blood lead level of adults are 5µg/dl but if the result is elevated above this, treatment may be recommended (31, 32). However, the measured concentration of lead exposure for this study will be compared with the non-exposed group based on both findings because exposure to lead usually accumulates and is stored in the blood, bone marrow, central and peripheral nervous systems, kidneys, and digestive system. According to OSHA, the maximum permissible exposure limit and action level for blood lead exposure surveillance in the air (workplace) and human blood within an average of 8 hours are 50µg/m3 and 30µg/m3 and 40 µg/dl, respectively (32, 33). Hence, measurement of blood lead level is a biomarker from blood,

hair, urine, teeth, or other body parts (7, 34-37). According to a previous study, the levels of lead in the blood, hair, and nails of the garage workers were 65.3 ± 41.9 μg /d1, 23.6 ±11.2 mg kg1, and 29.7 ± 14.5 mg kg1, respectively, whereas the levels in the non-exposed groups were 21.7 ± 17.6 μg/ dL1, 4.8 ±3.4 mg kg1, and 7.2 ±3.9 mg kg1 $^{-1}$ (7). The other study demonstrates that automotive garage workers in Jimma Town had mean blood lead levels that were significantly higher than those of the non-exposed groups with more than 10 μg/dL, and exposed workers had blood lead levels of 68% and 88% above 20 μg/dL with work durations of 6 and 10 years, respectively (22). A comparative cross-sectional study was done in Lagos State, Nigeria, to measure the blood lead levels of auto mechanics working in organized and roadside garages. About seventy-three (40.3%) of the organized garage workers were compared to 59 (34.3%) of the roadside workers, and those had a statistically higher median blood lead level (66.0 μg/dL) than the roadside workers (43.5μg/dl)(< 0.05)(25). According to the Bangkok, garage workers study, the average blood lead level in those who were exposed at work was significantly higher than in non-exposed groups (P< 0.05), such as 0.32 ±0.07 mol/l [6.59±1.48 g/dl], whereas 0.42 ±0.13 mol/l [8.79 ±2.65 μg/dl] and 0.58 ±0.07 μg/dl [12.03 ±6.99 mol/l] were recorded for the mechanics and dye sprayer groups, respectively(14).Since lead in blood has a half-life of 40 to 120 days but stays in bones for a long time, constituting on average 95% of the body's total lead burden, measuring blood lead levels is typically a valid indicator of lead exposure in the workplace(38). Biomonitoring or monthly testing of blood lead levels is performed in developed countries around the world to assess lead exposure for individuals or groups of workers but in developing countries, it is not applicable due to a laboratory, chemical reagents, trained human labor, and less recognition for lead exposure of workers in the workplace.

2.5. Analytical Method of Lead Determination

The biological samples of humans, whether exposed or not, are determined by using the atomic absorption spectrometry technique at a specific wavelength. There are common atomic absorption spectroscopies used around the world to determine the elemental composition of a sample by examining its electromagnetic spectrum; however, the most well-known atomic absorption spectrometry techniques are flame atomic absorption spectroscopy (FAAS), graphite furnace atomic absorption spectroscopy (GFAAS), inductively coupled plasma mass

spectroscopy (IC-PMS), and microwave plasma atomic emission spectroscopy (MP-AES)(39).Microwave plasma atomic emission spectroscopy (MP-AES) is a method for the determination of multiple trace elements at the same time. The device is well known for its low running cost, laboratory safety, better detection limit, linear dynamic range, and analysis speed, and it does not require expensive flammable gas compared to flame atomic absorption spectrometers (AAS) because the device is attaining nitrogen-fueled microwave plasma at temperatures nearing 6000 °C (5,000 °K) with up to 1 kW of power (40, 41).

2.6. Conceptual Framework

A conceptual framework is designed after reviewing different kinds of literature on blood lead levels among garage workers. This conceptual framework showed the associations of independent variables such as socio-demographic factors (age, sex, marital status, education, and Income), behavioral factors (safety trainings, use of personal protective equipment, personal habits, and hygiene practice), and occupational characteristics (daily working hours, service years, kinds of occupational jobs, and work practice) on dependent variable (Blood Lead Level) among the garage workers (Fig. 1).

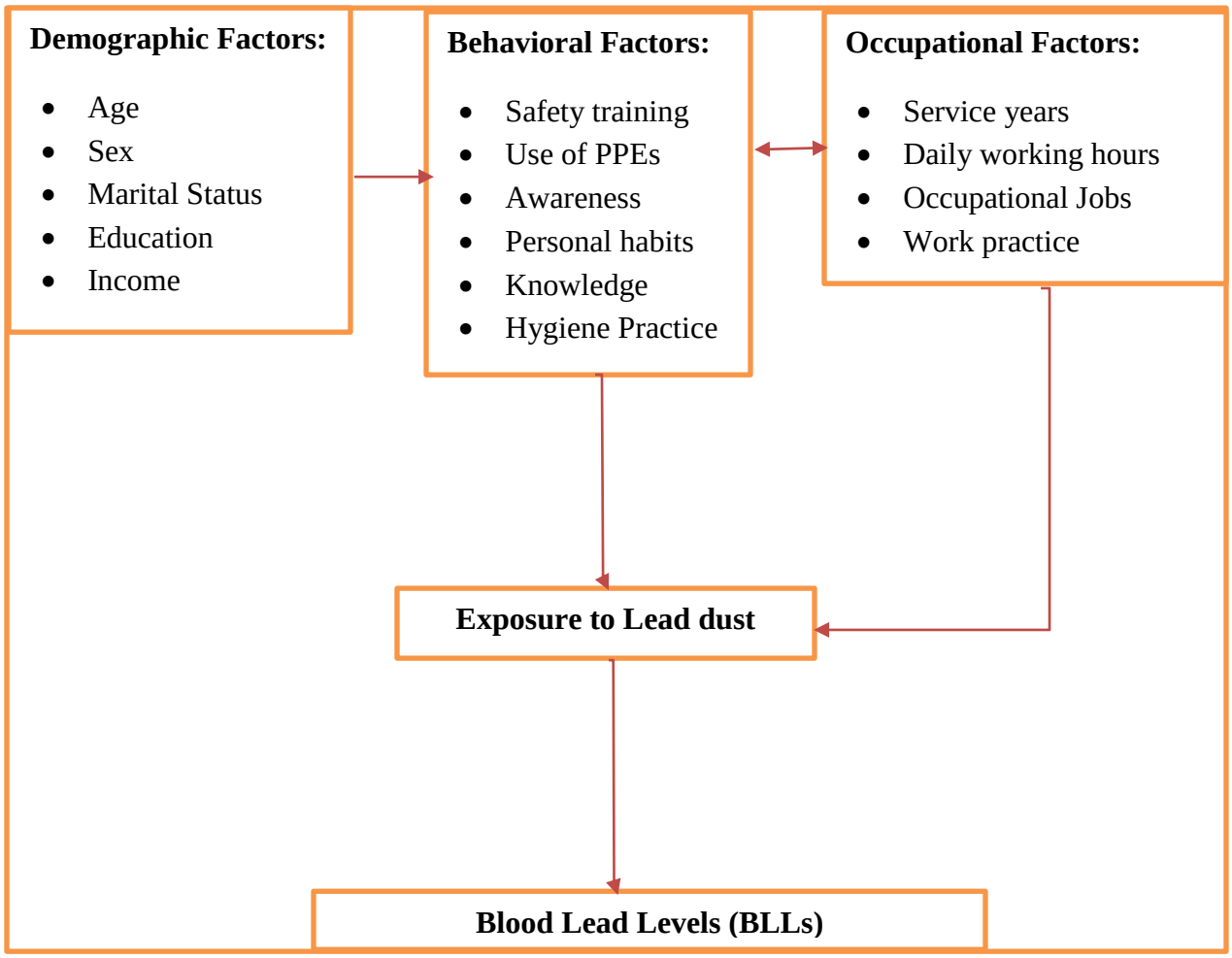

Figure 1:Conceptual framework for blood lead levels (BLLs)

Sources: Adapted after reviewing different literature on lead exposure (12, 13, 22, 25, 42)

3. Objectives

3.1. General Objective:

The general objective of this study is to assess occupational lead exposure levels in blood among Anbessa city bus service enterprise garage workers and associated factors in Addis Ababa, Ethiopia

3.2. Specific Objectives:

1. To compare lead exposure levels in blood between the exposed groups (employees at the Anbessa city bus service enterprise garage sites) and the non-exposed groups (non-garage workers who are working in EPHI as office workers).
2. To investigate the relationship between lead exposure levels in blood and associated factors that can contribute to occupational lead exposures.

4. Materials and Methods

4.1. Study Area and Period

The study was carried out in Addis Ababa, Ethiopia, among garage workers in the Anbessa City Bus Service Enterprise (ACBSE) from May to July 2023. The Anbessa City Bus Service Enterprise in Addis Ababa is one of the oldest and largest modern public service enterprises in the city. The Enterprise was established 80 years ago, during Emperor Haile Selassie's reign. Currently, it has four standard garage sites at Yeka sub-city (Gerji), Gulelle sub-city (Shegole), Nefas Silk sub-city (Jemo), and Kality sub-city (Kality). There were approximately 164, 101, 117, and 148 active garage workers in each garage site (Gerji, Shegole, Jemo, and Kality), respectively.

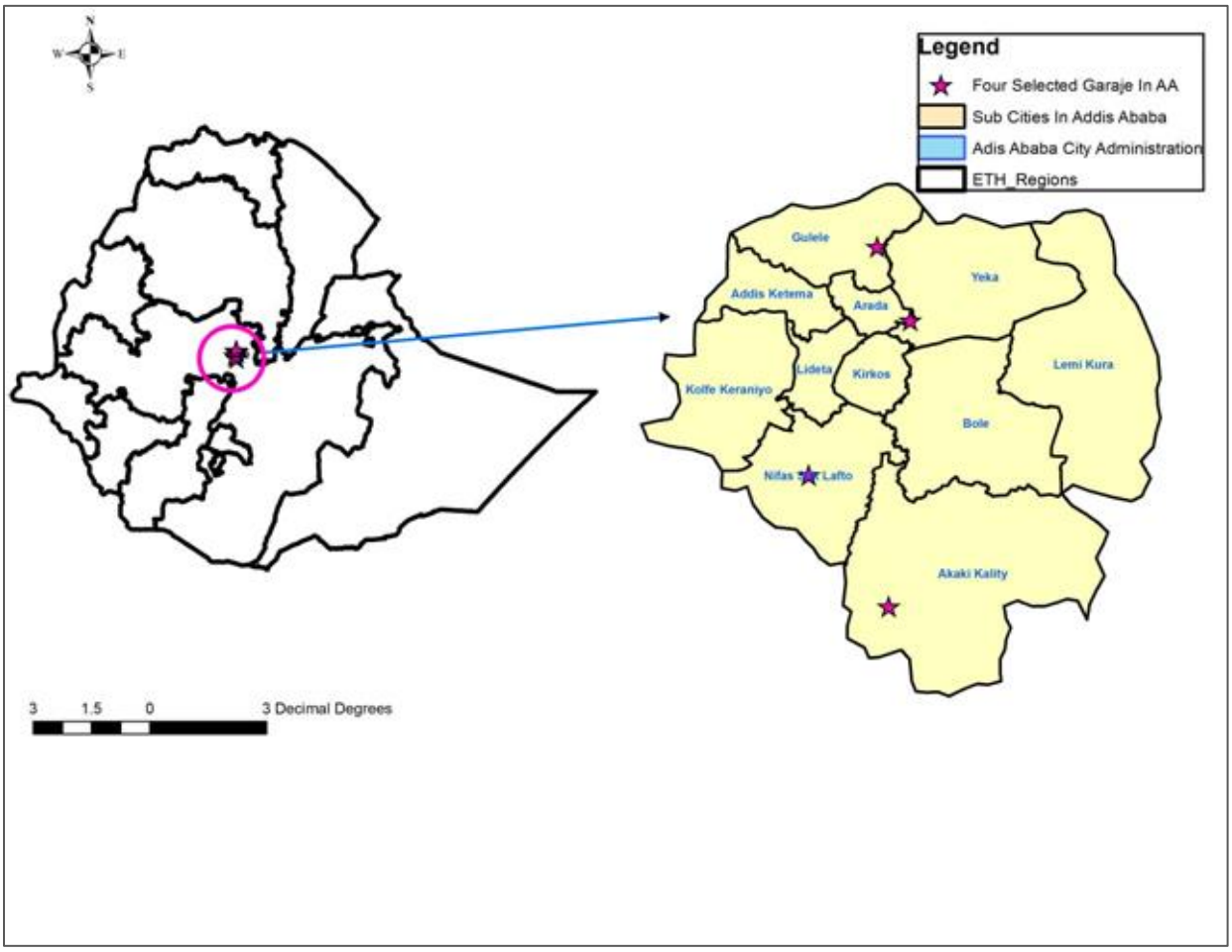

Figure 2: Study area of the Anbessa bus city service enterprise garage sites in four sub-cities of Addis Ababa

4.2. Study Design

A comparative cross-sectional study design was used to evaluate occupational lead exposure between Anbessa City bus service enterprise garage workers and comparison groups (non-garage workers who are working in Ethiopia Public Health Institute (EPHI) as Office workers without any intended occupational lead exposure).

4.3. Source and Study of Population

The source population of the study were all the Anbessa City Bus Service Enterprise (ACBSE) garage workers. the sources population of the comparison group were all office workers of the Ethiopian public health institute living in Addis Ababa. The office workers were selected as a comparison group if they were not exposed to lead exposure previously and they were approximately matched with socio-demographic characteristics, particularly with age and sex as garage workers(2, 35). The population of the study participants were all randomly selected workers who were engaged in electricians, painters, mechanics, and welders occupational job positions in the four branches of the Anbessa City Bus Service Enterprise (ACBSE) garage sites at Addis Ababa and the compassion groups were office workers if they had not previously occupational lead exposure histories. There were inclusion and exclusion criteria to choose the study subjects.

Inclusion Criteria:

1. Subjects must be permanent workers and have at least 18 years old to participate in the study.
2. Workers should have at least one year of work experience in garage works (2, 35)
3. Subjects should be involved in one of the following job positions: mechanics, electricians, welders, and painters.

Exclusion Criteria:

1. Subjects who were rotated from one job position to another were excluded.
2. Subjects with a history of chronic cases, such as diabetes or hypertension, who were following their health status in hospitals were excluded.

4.4. Sample Size Determination

For the first Objective: For blood lead concentration

Based on a prior study among Bangkok garage workers, the required sample size for the first objective was estimated using the mean and standard deviation of blood lead levels (BLL) for the exposed group (0.42±0.13µmol/L) and the unexposed group (0.32±0.07µmol/L) (14).

The sample size was determined using a double mean-standard deviation comparison formula with a ratio of 1:1 for the exposed and non-exposed groups (46-48).

$$\text{Sample Size (n)} = \frac{(\sigma_1^2+\sigma_2^2)(Z_\beta+Z_{\alpha/2})2}{(d)2}$$

Where n: the desired sample size per group.

$Z_{1-\alpha/2}$: the confidence level at 95% CI it is 1.96.

$Z_{1-\beta}$: the desired power at 95 % (1.64)

σ_1: standard deviation of exposed groups (0.13µmol/L) (49)

σ_2: standard deviation of unexposed groups (0.07µmol/L)

d: Mean difference for both exposed and unexposed groups (0.1 µmol/L)

Thus, $n=\frac{(0.13^2+0.07^2)(1.\dot{6}4+1.9\dot{6})2}{(0.42-0.32)2}$=29 for each group

By adding a 15% to non-response rate, the final sample size for each group was 34, with a total of 68 sample size. The sample size calculation was performed using Open Epi Version 3 software calculator for both objectives **(http://www.openepi.com/SampleSize/SSMean.htm)**.

For the Second objective: Finding determinants of BLL

The sample size for the second objective was also determined using the following formula between 6-10 and >=15 years of work experiences for exposed groups. Hence, $\mu_1 \pm SD_1$ = 60.8 ± 44.4µg/dl and $\mu_2 \pm SD_2$= 89.1 ± 47.0 µg /dl respectively(50).

$$\text{Sample Size (n)} = \frac{2SD2(Z_\beta+Z_{\alpha/2})2}{(d)2}=41$$

Where n: number of sample size to be determined

σ_1: standard deviation between 6-10 years of work experience(7)

σ_2: standard deviation >=15 years of work experience.

$Z\alpha/2$:1.96 confidence level at CI 95 % (1.96)

Z_β: the desired power at 80% (0.84)

d: Mean difference between 6-10 and >=15 years of work experiences for exposed groups

By considering 90% to response rate, the final sample size who had between 6-10 and >=15 years of work experience is equal to 45 for each group**.** As a result, the final sample size was 90, which was greater than the first objective sample size calculation; however, due to a lack of resources and laboratory reagents, the study was conducted on the first sample size calculation

4.5. Sampling Procedures

A stratified random sampling technics was employed to identify the study subjects. Based on the levels of exposure to lead between subjects are not uniform. Hence, the exposed groups were divided into four different occupational job position activities (mechanics, electricians, painters, and welders). The calculated sample size of exposed groups was allocated to each garage site using a proportional allocation technique to population size by selecting each participant using simple random sampling from a list of workers for salary payments (sampling frame) (Table 1).

Table 1:Sample size proportional allocation based on occupational job position of garage and non-garage workers in four garage sites of ACBSE and EPHI in Addis Ababa, Ethiopia, 2023

No.	Major Garage Sites	Number of Garage workers	Sampled Workers
1	**Gerji**	**164**	**10.5 (11)**
Job Position	Mechanics	87	5.6 (6)
	Electrician	20	1.3 (1)
	Welders	49	3.1 (3)
	Painters	8	0.5 (1)
2	**Jemo/Mekanissa**	**117**	**7.5 (8)**
Job Position	Mechanics	46	2.9 (3)
	Electrician	15	1.0 (1)
	Welders	42	2.9 (3)
	Painters	14	0.9 (1)
3	**Kality**	**148**	**9.5 (10)**
Job Position	Mechanics	48	3.1 (3)
	Electrician	46	2.9 (3)
	Welders	28	1.8 (2)
	Painters	26	1.7 (2)
4	**Shegolle**	**101**	**6.5 (7)**
Job Position	Mechanics	45	2.9 (3)
	Electrician	26	1.7 (2)
	Welders	30	1.9 (2)
	Painters	0	0
	Overall	**530**	**36**
5	**EPHI (non-garage site)**	**500**	**34**
Job Position	Health Professionals	320	21.8 (22)
Job Position	Supportive Staffs	180	12.2 (12)

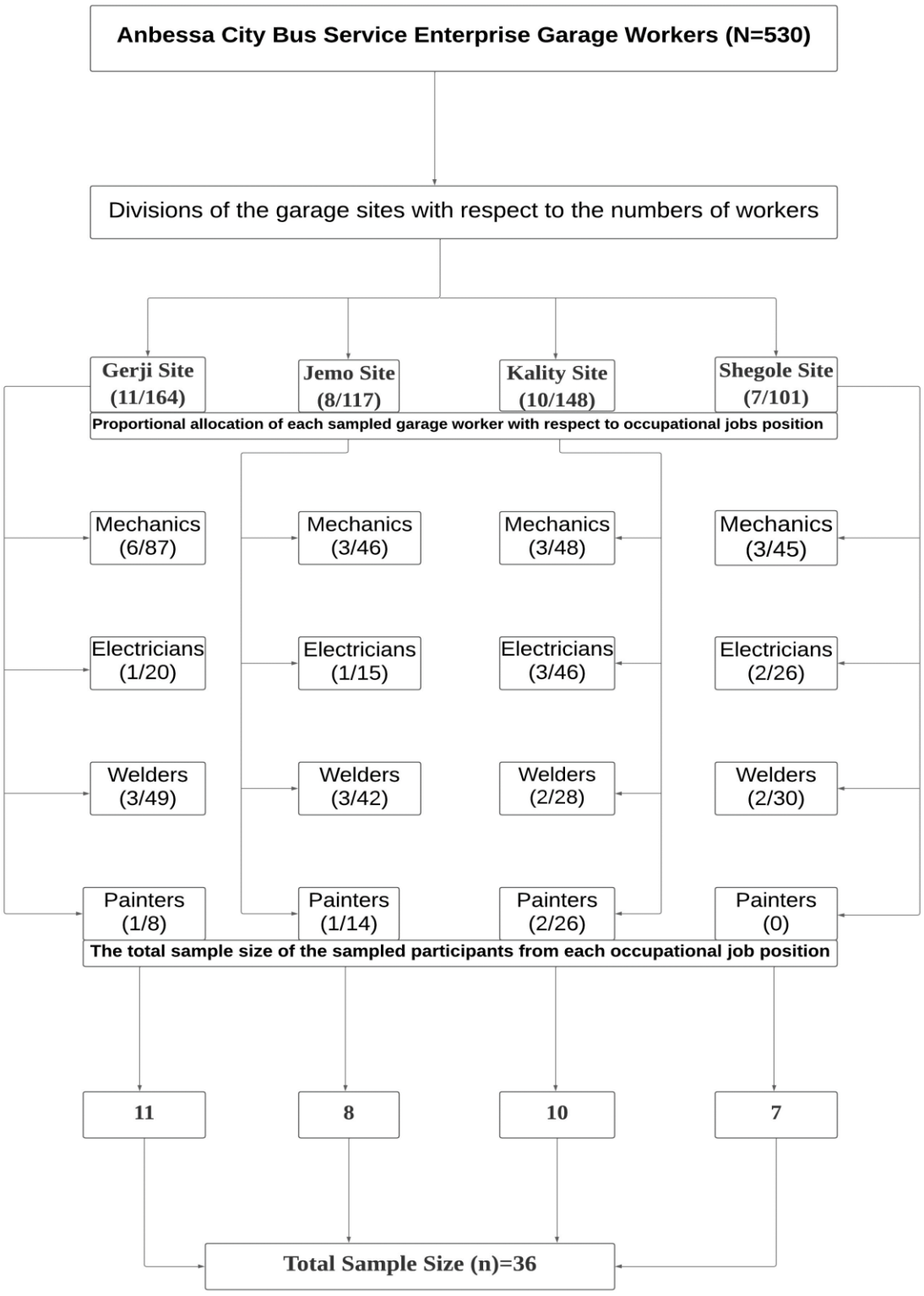

Figure 3: Schematic presentation for the sampled workers

source: created by own

4.6. Data Collection Techniques

Questionnaire Administration

Interviewer-administered questionnaires were developed and modified from published literature (12-14, 22, 25). To maintain consistency, the questionnaire was written in English and translated into Amharic, then back into English. The questionnaire was tested on 5% of the total sample size to modify contextual, quantitative, and terminological effects on participants before the actual data collection was started. Then, socio-demographic, behavioral, and occupational characteristics of respondents were collected in parallel with blood sample collection for both exposed and unexposed groups by trained medical laboratory experts to assess the lead exposure factors.

Blood Sample Collection, Transportation and Handling

For blood sample collection, transportation, handling, and storage, the standard laboratory procedure manual was applied (51). To reduce the contamination of samples, the health facility of the enterprise was used as a blood collection site in the workplace. About 4 ml of whole blood samples were collected from both exposed and unexposed groups by medical laboratory professionals using a separate vacutainer tube, alcohol, and gloves for every individual. The venous whole blood sample contains Pb-free tubes and "EDTA (K2)" (as an anticoagulant) and is homogenized by handshaking to prevent clotting (51). The samples were transported to the Ethiopian Public Health Institute (EPHI) laboratory each day using a cold box and stored at 4 °C and frozen at -20 °C until the time of analysis. The blood samples were measured using microwave plasma atomic emission spectroscopy (MP-AES) with model 4210 at a wavelength range of 180–780 nm for analysis of blood lead levels (40, 41).

Apparatus and Equipment

The laboratory apparatus that was used for this study included: heparinized blood collection tubes, vacutainer needles and holders, tourniquets and alcohol swabs, different sizes of beakers, measuring cylinders, metal-free test tubs, digestion flasks, and different sizes of volumetric flasks, gloves, analytical balance, hotplate from 110 to 250 °C, microwave plasma atomic emission spectroscopy (MP-AES) used for sample analysis. Microwave plasma atomic emission

spectroscopy (MP-AES), just like flame atomic absorption spectroscopy (FAAS), quantifies the concentration of trace elements by comparing its emission with known concentration samples by plotting a calibration curve. The instrument has an elemental determination by using pure nitrogen gas as a source and autosampler software (Agilent Model 4210) with a high sensitivity detection limit, and it has a high capacity to analyze about 500 samples per week and four elements per sample. However, all glassware and plastic ware that contacts standards, samples, or blanks were cleaned with detergent and soaked for 12 hours in 10%(v/v) nitric acid (HNO_3**)** and rinsed thoroughly with deionized water before use.

Chemicals and Reagents

All reagents and chemicals were analytical-grade unless otherwise stated. This was done based on the fourth edition of the NIOSH manual of analytical methods (NMAM) on method 8005 Issue 2 (1994) and various literature for blood or tissue and urine procedures measurement (50, 52, 53). Thus, the analytical laboratory required chemical reagents such as commercially available 1000 mg/L of lead (Pb) stock solution, nitric acid (70%), perchloric acid (70%), hydrogen peroxide (30%), sulfuric acid (96%), hydrochloric acid (37%) and deionized water were used for the sample preparation

Sample Preparation and Digestion Procedures

Each sample was prepared in accordance with procedures validated by various published literature and the NIOSH in the fourth edition of the Manual for Analytical Methods (NMAM) for the determination of blood or tissue procedures on Method 8005 Issue 2 (1994) (50, 52, 53). Based on these procedures, each sample was analyzed in the Ethiopian Public Health Institute's (EPHI) accredited nutritional laboratory and the Ethiopian Food and Drug Authority (FDA) accredited laboratory by using the laboratory protocols and procedures. As a result, about 2 ml accurately measured portion of each whole blood sample was transferred into a digestion beaker, and 10 ml of a freshly prepared mixture of concentrated nitric acid and hydrogen peroxide (HNO_3(70%)- H_2O_2 (30%)) (6:4 v/v) was added by standing for 10 minutes. The beakers /flasks were covered with watch glass and then heated at 110 °C for 1- 2 hours. The digests were again treated with a few mixtures of nitric acid and hydrogen peroxide while increasing the hotplate temperature to about 250 °C until the digestion/clear solution was completed/obtained. Then the

excess acid mixture was evaporated until the clear solution remained approximately to semi-dry mass. Then, cooled and filtered the digestion of blood solution and transferred each filtered clear solution to a volumetric flask (100ml) by diluting to the mark with deionized water. At the same time and procedures, field and reagent blanks (without samples) were prepared in triplicate using deionized water. Then, each prepared clear sample solution was stored and refrigerated at -4 °C until the laboratory analysis will be done by microwave plasma atomic emission spectroscopy (MP-AES)([50](), [52]()). Finally, each lead level in a blood sample was measured by microwave plasma atomic emission spectroscopy (Agilent model 4210) at a wavelength range of 405.781 nm after calibrating the instrument.

4.7. Study Variables

Dependent Variable:

- Blood Lead Level (BLL)

Independent Variables:

- Socio-demographic factors (age, sex, marital status and income)
- Behavioral factors (safety training, lead awareness, use of PPEs, personal habits, hygiene practice, and knowledge of lead exposure)
- Occupational factors (daily working hours, service years, kinds of occupational jobs and work practice)

4.8. Operational Definitions

Blood lead levels (BLLs): workers are exposed to lead exposure if the blood lead level is greater than 40.0µg/dl (31).

Duration of exposure: Chronological years that workers have spent years at work(3).

Lead exposure: the amount of occupational lead agent that can expose workers (54).

Occupational lead exposure: occurs as a result of occupational tasks (54, 55).

Inhalation: workers can absorb toxic vapors, mists, gases and dust of lead exposure (31).

Ingestion: When workers eat or drink, they digest chemical exposures with food and water (31).

Workplace awareness: Ability of workers to protect themselves from lead exposures (54, 55).

Acute effects: anybody who is exposed to chemical hazards for 24 hours or less (3, 56)

Chronic effects: anybody who is exposed for months or years (3, 56)

Occupational disease: a disease that occurs in the workplace under specific conditions (56).

Work safety: health and safety circumstances of the garage environment (54, 55)

Routs of Lead Exposure: Routes of lead exposure can enter the human body through inhalation, ingestion, or skin contact **(**2**,** 3**).**

Similar age and sex groups: individuals who are involved in this study but do not have occupational lead exposure histories as garage workers(2, 50)

Toxicity of lead: the degree of lead that can cause poisoning for workers in garage or others(31)

Mechanics: Persons who repair and inspect or replacing of the spare parts including engine of the city buses for the good running condition (50)

Electricians: The persons, who install, inspect and maintain electrical parts of the city buses(50)

Welders: The persons who is fabricating the city buses bodies using a high heat(50, 57).

Painters: The persons who is paining the city buses surface with paint after the body parts fabrication are finished (50)

4.9. Data Quality Assurance and Control

Each blood sample was collected using vacationer tubes containing 7.2 mg of K2EDTA (an anticoagulant agent) by trained and qualified medical laboratory professionals. The tubes were coded immediately after drawing the blood samples and then transported and stored at 4 degrees Celsius following the standard operating procedures (SOP) for laboratory analysis. All equipment's used for the laboratory were cleaned and labelled to minimize contamination.

The instrument (MP-AES) was calibrated by preparing five series working standards of Lead 20(µg/dl), 40(µg/dl, 60(µg/dl), 80(µg/dl) and 100(µg/dl) from 1000mg/l commercially available stock solution of lead to check the quality control. The calibration standard solutions were running at a specified wavelength of lead (405.781nm) by adjusting the instrument with blanks. The analysis was given the following best-fitted line graph (Figure 1). The graph regression equation = 45.624X + 4.2194 and R^2=0.9994 where X=concentration (µg/dl), Y=Intensity (cps), R^2 is correlation coefficient of the calibration curve, 45.624 slope and 4.2194 is intercept. As it observed below in the plotted linear line graph, there was a good relationship between the concentration and intensity of lead standard solution with effective good calibration of the instrument.

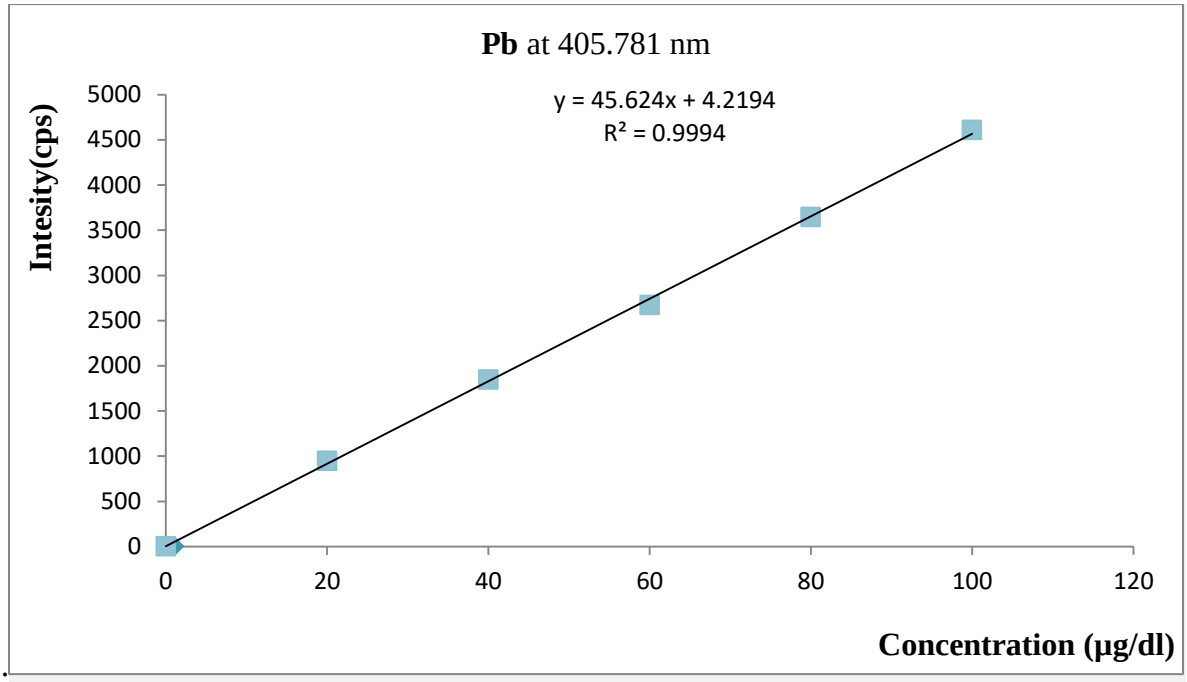

Figure 4:Standard calibration curve of the MP-AES instrument for lead level analysis in blood

The other testing of the quality control, recovery tests were checked and obtained using the selected blood samples with the sample procedures as sample preparation for the spiked sample and un-spiked sample with a known sample solution. Then, the percentage recoveries were calculated as:

$$\% \text{ Recovery} = \frac{Mean\ Spiked\ Value - Unspiked\ Value}{Standard\ of\ Spiked\ added} * 100$$

From the random selected of blood samples, the four calculated percentages recoveries results were 110%, 109.2%, 94.25%, and 85 %, hence, the mean percentage recovery was 99.61% had a conventionally acceptable precision and accuracy with the percentage recovery range (80% - 110%) of the samples (50, 58).

During the laboratory analysis, the measured lead level in blood was carried out in duplication to minimize error, and taken the average results for both the exposed and non-exposed groups. In addition to the Ethiopian public health institute (EPHI) accredited laboratory, another cross-checking Ethiopian Food and Drug Authority (FDA) accredited laboratory was used to check the accuracy and precision of each obtaining sample result. Hence, about 40% of blood samples were analyzed in Ethiopian Food and drug authority (FDA) laboratory with the same instrument likes the EPHI laboratory instrument by using the same time and the same procedures. Since the sample results that were done in that laboratory were approximately the same.

Data Management

To get consistency in the data collected from study subjects and lab results, two-day training was given for two supervisors, two lab experts, two data collectors, and two lab cleaners, beginning with a hint about the purpose of the study, the data collection tools, and ethical concerns during data collection. The investigator and supervisors checked the data for completeness on a daily basis. The lab experts then received the blood samples from the data collectors after the supervisors and principal investigator approved each collected sample. All the data were cleaned on each day of laboratory work to identify unexpected and unclear values. The data were entered and organized into an Excel format, and the analysis was done using SPSS version 26 by cleaning the data. The normality assumption was made using the Shapiro-Wilk test. An independent sample t-test was used to compare the non-exposed and exposed groups for those

that fulfilled the assumptions to know the significant difference among exposed and non-exposed groups.

4.10. Data Analysis

First Specific Objective:

The statistical data analysis was done using SPSS (version 26) software. Descriptive statistics were used to display the demographic, behavioral, and occupational characteristics. The results were presented in the form of frequency, mean, percentages, and cross-tabulation. The mean values of lead levels in blood were analyzed using one-way ANOVA and an unpaired t-test to compare exposed and unexposed groups of blood lead levels.

Second Specific Objective:

Multiple linear regression analysis was used to test the association between the dependent variable (blood lead level) and each independent variable (service years, age, daily work hours, and other independent variables) by doing a first simple linear regression analysis of the outcome variable with each independent variable to select those variables with a p-value below 0.2. Then multiple linear regression analysis was run to determine the impact of lead exposure factors on blood lead level by considering the p-value < 0.05 as statistical significance. To apply the regression method, all assumptions for linear and multiple regressions were checked. Diagnostics for multicollinearity among the independent variables were done using the variance inflation factor. Those independent variables with variance inflation-factor values >10 were taken as indicative of multicollinearity and removed from the multiple linear regressions.(59). Finally, the slope of the regression parameters was expressed as beta coefficients with 95% of the confidence interval to determine the effects of independent variables on blood lead level(3).

4.11. Ethical Consideration

The ethical approval of the study was obtained from the Ethical Review Board of Addis Ababa University, College of Health Sciences, School of Public Health (Ref. No.: SPH/154/23). An official letter was written from School of Public Health to the enterprise to obtain permissions. For this study, ethical considerations are critical. Hence, all respondents were informed about the purpose of the study and why it was being conducted on garage workers. Trained and experienced medical laboratory experts were activated for blood sample collection by telling the facts to participants without enforcement. The respondents have the right to give a sample or refuse it at any time voluntarily, according to their informed consent. The blood sample and the questionnaires were coded to ensure the confidentiality of the data. According to the World Medical Association Helsinki Protocols of 2013, all data and information obtained from the participants were kept confidential. The collected blood samples were used for this study only (60). When we obtained consent from each participant, the blood specimens were collected using safe vacutainer needles and gloves for each individual participant**.** The study participants were advised to use exposure prevention methods and visit health facilities for regular checkups after their results known.

4.12. Dissemination of the Results

The final results of this study will be presented to Addis Ababa University staff at the thesis defense date. After the finalization of the study; the result will be disseminated to the public through the Addis Ababa University portal system. After the research is finished, the final findings will be presented to the Enterprise and employees. Finally, the research will be published in a peer-reviewed journal that will be accessible around the world for the scientific societies so that it may use as literature and reference for further study on automotive garage workers.

5. Results

The study was conducted among workers in the city bus garage in Addis Ababa, Ethiopia, to assess the blood lead levels of Anbessa City Bus Service Enterprise garage workers and associated factors in Addis Ababa, Ethiopia, by comparing them with non-garage workers. In this study, the blood lead levels for both garage and non-garage workers have been reported, and the associated factors for the elevation of blood lead levels have been presented.

5.1. Socio-demographic and economic factors of the study participants

Of the total 70 study participants, 36 (31 males and 5 females) were engaged in the Anbessa City Bus Service Enterprise (ACBSE), known as the garage workers (Exposed Groups), and the other 34 (28 males and 6 females) carried out their activities in government offices (the Ethiopian Public Health Institute), known as the less exposed workers (unexposed groups). The mean age of the exposed groups was (39.0 ±7.5) years with a range of 27–54 years, whereas of the unexposed groups mean age was (37.9 ±6.1) years with a range of 28–49 years. The majority of the exposed groups, 21 (58.3%), had diplomas as compared to the unexposed groups, who had degrees and above, 29 (85.29%). Regarding marital status, 29 (80.6%) of the exposed and 26 (76.5%) of the unexposed groups were married. The majority of 26 (72.2%) exposed and 31 (91.2%) unexposed groups were paid a monthly income above 6,000 (Ethio. Birr) (Table 2).

Table 2: Socio-demographic and economic factors in exposed groups (n = 36) and unexposed groups (n = 34) in Addis Ababa, Ethiopia, 2023

Variables	Exposed Group n (%)	Unexposed Group n (%)	Statistical Analysis	
			X^2	p-value
Age (yrs.):				
18-30	8 (22.2)	6 (17.7)	3.18	0.2
31-44	16 (44.4)	22 (64.7)		
>=45	12 (33.3)	6 (17.7)		
(Mean ±SD) years	**(39.0±7.5)**	**(37.9±6.1)**		
Sex:				
Male	31 (86.1)	28 (82.4)	0.19	0.67
Female	5 (13.9)	6 (17.6)		
Education:				
Below Diploma	7 (19.4)	4 (11.8)	30.89	0.001*
Diploma	21 (58.3)	1 (2.94)		
Degree and above	8 (22.2)	29 (85.29)		
Marital Status:				
Single	7 (19.4)	8 (23.5)	0.17	0.67
Married	29 (80.6)	26 (76.5)		
Monthly income:				
<=6,000	10 (27.8)	3 (8.8)	4.15	0.04*
> 6,000	26 (72.2)	31 (91.2)		

5.2. Occupational job position of the study participants

According to a one-way ANOVA test, the participants of garage workers for this study were engaged in mechanics, electricians, welders, and painters occupational job position activities were not statically significant (P>0.05). However, the higher 15 (41.7%) of exposed groups were engaged in mechanics occupational job positions, while the lowest 4 (11.1%) of exposed groups were engaged in the occupational job position of painters. For the comparison parts of the exposed groups, 22 (64.7%) and 12 (35.3%) of the unexposed groups were engaged on a non-garage office work with health professionals and supportive staff occupational job positions respectively in the government office of the Ethiopian Public Health Institute (Table 3).

Table 3: Occupational job position of exposed groups (n = 36) and unexposed groups (n = 34) in Addis Ababa, Ethiopia, 2023

Group	Occupational Job position	n (%)	AM (SD) µg/dl	GM (GSD) (µg/dl)	ANOVA, p-value
Unexposed Group	Health workers	22 (64.7)	15.3 (10)	14 (2)	0.7
	Supportive staffs	12 (35.3)	13.9 (10.1)	13.9 (2.1)	
Exposed group	Mechanics	15 (41.7)	30.6 (12.1)	28.1 (1.6)	0.33
	Electricians	7 (19.4)	32.6 (15.2)	28.3 (1.9)	
	elders	10 (27.8)	24.1 (10.7)	21.4 (1.8)	
	Painters	4 (11.1)	35.5 (8.3)	34.8 (1.3)	

5.3. Behavioral factors and use of PPE among the study participants

Regarding PPE users, 17 (47.2%) of exposed groups did not use any types of personal protective equipment (PPEs), whereas 25 (73.5%) of the unexposed groups did not use any types of PPE at work. However, the unexposed groups did not have mandatory to wear PPE except the risky work activities. Regarding lead awareness, 22 (61.1%) of exposed groups were aware about lead exposure as a hazard, while 23 (67.7%) of unexposed groups were not aware in their workplace. The participants in exposed and unexposed groups who had taken safety trainings at work were only 14 (38.9%) and 6 (17.6%), respectively. Regarding exposure prevention methods, 21 (58.3%) of exposed groups were applied lead exposure prevention methods such as washing hands before eating, changing clothes, and taking shower after the completion of work, while only 11 (29.4%) of the unexposed groups did use the lead exposure prevention methods at work. In terms of addiction to habits, the majority of exposed groups and unexposed groups had no bad addiction habits; however, 15 (41.7%) of exposed and 5 (14.7%) of unexposed groups were dependable on addiction habits such as drinking alcohol or smoking cigarette at work. About 24 (66.7%) of the exposed groups did not follow the occupational health and safety rules and regulations (Safety practices) in the workplace, while 21 (61.8%) of the unexposed groups did apply the safety practices (Table 4).

Table 4: Behavioral factors and use of PPE in exposed groups (n = 36) and unexposed groups (n = 34) in Addis Ababa, Ethiopia, 2023

Variable	Exposed Group n (%)	Unexposed Group n (%)	Statistical Analysis X^2	p-value
PPE Reporting:				
Yes	19 (52.8)	9 (26.5)	5	0.03*
No	17(47.2)	25 (73.5)		
Lead Awareness:				
Yes	22 (61.1)	11 (32.4)	5.8	0.02*
No	14 (38.9)	23 (67.7)		
Training on OSH:				
Yes	14 (38.9)	6 (17.6)	3.9	0.05*
No	22 (61.1)	28 (82.4)		
Exposure prevention Methods:				
Yes	21 (58.3)	11 (29.4)	4.8	0.03*
No	15 (41.7)	23 (70.6)		
Addiction of bad habit:				
Yes	15 (41.7)	5 (14.7)	6.2	0.01*
No	21 (58.3)	29 (85.3)		
Knowledge on lead hazards:				
Yes	10 (27.8)	18 (52.9)	4.6	0.03*
No	26 (72.2)	16 (47.1)		
Safety Practice in work place:				
Yes	12 (33.3)	21 (61.8)	5.6	0.02*
No	24 (66.7)	13 (38.2)		
Prior employment in garage:				
Yes	31 (86.1)	4 (11.8)	38.7	0.001*
No	5 (13.9)	30 (88.2)		

5.4. Comparison of blood lead levels among the study participants

For this study, an independent sample t-test was used to compare the mean blood lead level for both exposed and unexposed groups. Hence, according to the independent sample t-test, there was a significant difference between the two groups (t (68) = 5.8, P< 0.001), with the mean blood lead levels for exposed groups (M = 29.7, SD = 12.2, median = 27.5, and range = 6–52.5) µg/dl being higher than the unexposed groups mean blood lead levels (M = 14.8, SD = 9.9, median = 15, and range = BDL-32.5) µg/dl. The magnitude of the two groups mean difference (Mean difference =14.9, at 95% CI: 9.6 to 20.2) was statistically significant (Table 5).

Table 5: Comparison of blood lead levels between exposed groups (n = 36) and unexposed groups (n = 34) in Addis Ababa, Ethiopia, 2023

Group	n	Mean (SD) µg/dl	95% CI (µg/dl)	Range (µg/dl)	P-value
Exposed Group	36	29.7 (12.2)	11.4 -18.3	6 -52.5	
Unexposed group	34	14.8 (9.9)	25.6 -33.8	BDL- 32.5	< 0.001

** Equal variances assumed*
BDL= lower detection limit (0.1 µg/dl) of the instrument

According to the one-way ANOVA test, 2 (5.6%), 26 (72.2%), and 8 (22.2%) of the exposed groups mean blood lead levels were 6.8 ±1.1 µg/dl, 26.2 ±7.3 µg/dl, and 46.9 ±3.9 µg/dl, respectively, whereas 11 (32.4%) and 23 (67.6%) of the unexposed groups mean blood lead levels were 3.3±3 µg/dl and 20.3 ±6.7 µg/dl, respectively (Table 6).

Table 6: Categorization of BLLs of workers according to OSHA recommendation limits

	Exposed Groups (n=36)			Unexposed Groups (n=34)		
BLL (µg/dl) Categories	n (%)	BLL (Mean± SD) µg/dl	ANOVA, P-value	n (%)	BLL (Mean ±SD) µg/dl	ANOVA, P-value
< 10 (normal)	2 (5.6)	6.8 ±1.1		11 (32.4)	3.3±3	
10 -40 (acceptable)	26 (72.2)	26.2 ±7.3	P<0.001	23 (67.6)	20.3 ±6.7	P<0.001
>40 (dangerous)	8 (22.2)	46.9 ±3.9		-	-	

5.5. Relationship of Associated factors to BLLs using simple linear regression model

Socio-demographic and occupational factors among the exposed groups

To assess the effect of each socio-demographic and occupational factor among the garage workers on blood lead level, a simple linear regression model was used with the estimation equation. Y=β0+β1X1, where Y-dependent variable (BLL) and X1-independent variable, three of the socio-demographic and occupational factors of variables such as age, daily working hours, and service years were statistically significant (p< 0.001) as the mean blood lead level of the workers were increased by 1.3 g/dl, 8.11 μg/dl and 1.g/dl, respectively; however, sex and monthly income were not insufficient to be significant (P> 0.05) (Table 7).

Table 7: Effect of socio-demographic and occupational factors on blood lead levels using simple linear regression analysis among exposed groups (n=36) in Addis Ababa, Ethiopia, 2023

Types of Variables	N=36	Coefficient (β)	S. E	LB at 95% CI	UB at 95% CI	R^2	F-value
Constant		-19.8	7.0	-34.0	-5.5	0.60	51.4
Age in years		1.3*	0.2	0.9	1.6		
Constant	5	24.0	5.4	12.9	35.0	0.04	1.3
Sex (male)	31	6.6	5.8	-5.2	18.5		
Constant	10	30.5	2.4	25.6	35.4	0.01	0.4
Monthly income (>6000)	26	-2.9	4.6	-12.3	6.3		
Constant		-38.7	14.7	-68.6	-8.7	0.39	21.8
Daily Working Hours		8.1*	1.7	4.6	11.7		
Constant		6.7	3.2	0.1	13.2	0.64	60.9
Service years		1.8*	0.2	1.3	2.3		

*LB: lower bound; UB: upper bound; * significant at p<0.01; S.E: standard error*

Behavioral factors among the exposed groups

The mean blood lead level difference among exposed groups who were coded with yes (1) and no (0) responses was assessed. Each variable had significant impact on blood lead level. However, workers who were dependable on addiction habits like consumption of alcohol or smoking cigarettes had no sufficient significant (P>0.05) difference directly on blood lead exposure level. The non-user of PPE in exposed groups had higher mean blood lead level difference (16.8 μg/dl) with a high statistical significance (R^2=0.49, P<0.001) difference than that of the PPE users in exposed groups. Regarding lead awareness, the blood lead level increased by 8.9 μg/dl mean blood lead level difference in the unawareness of exposed groups as compared the awareness exposed group with statistically significant (P<0.05). There was a significant difference (P<0.05) in blood lead level between in lead exposure prevention method users and non-users among the garage workers. As the lead exposure prevention methods users were increased by one unit, the mean blood lead level difference decreased by 9.9 μg/dl however, the mean blood lead difference in non-prevention users increased. The workers that were not involved in safety practice had higher mean blood lead difference (9.8 µg/dl) than those who were involved in safety practice with significant difference between them (P<0.05). Regarding OSH, the mean blood lead level difference among exposed groups decreased by 10.8 µg/dl who were taking trainings on OSH than those who were not taking trainings (P<0.05). There was a highly statistically significant difference (P<0.05) with mean blood lead level by increasing 13.8 µg/dl as prior garage employee increased among the exposed groups (Table 8).

Table 8: Impacts of behavioral factors on blood lead levels using simple linear regression analysis among exposed groups (n=36) in Addis Ababa, Ethiopia, 2023

Types of Variables	N=36	Coefficient(β)	S. E	LB at 95% CI	UB at 95% CI	R^2	F-value
Constant	17	38.6	2.2	34.2	42.9		
PPE reported (yes)	19	-16.8*	2.9	-22.8	-10.7	0.49	32.0
Constant	14	35.2	3.1	28.9	41.5		
Lead awareness (yes)	22	-8.9*	3.9	-16.9	-1.0	0.13	5.2
Constant (No)	15	35.5	2.9	29.5	41.4		
Exposure prevention methods	21	-9.9*	3.8	-17.6	-2.1	0.16	6.7
Constant (No)	26	33.2	2.1	28.8	37.6		
Knowledge on Lead hazards	10	-12.5*	4.1	-20.9	-4.250	0.22	9.5
Constant	22	33.9	2.4	29.1	38.7		
Training on OSH (yes)	14	-10.8*	3.8	-18.6	-3.1	0.19	8.2
Constant	24	32.9	2.3	28.2	37.7		
Safety Practice (yes)	12	-9.8*	4.0	-17.9	-1.6	0.15	5.9
Constant (No)	5	17.9	5.1	7.5	28.2		
Prior employment in garage	31	13.8*	5.5	2.7	24.9	0.16	6.4
Constant	21	27.9	2.7	22.6	33.4		
Addiction habits (yes)	15	4.2	3.9	-4.1	12.6	0.03	1.1

*LB: lower bound; UB: upper bound; * significant at p<0.05; S.E: standard error*

5.6. Relationship of Associated factors to BLLs using multiple linear regression model

The selected independent variables which shown that the p-value <0.2 in simple linear regression analysis and had fulfilled the regression assumptions were taken into multiple linear regression analysis. In multiple linear regression analysis, daily working hours, service years (work experience) and prior employment in garage had shown statistically significant association with the blood lead level of exposed groups, however other predictors directly had not impact to increase or decrease the blood lead level of the garage workers (P>0.05). Using a multiple linear regression analysis, the blood lead level of the exposed groups was assessed and the general model summary results were (R^2 = 0.856, Adjusted R^2 =0.798, F (10,25) =14.87, P<0.001). Then, we can write the multiple linear regression model summary equation for significant predictors on blood lead level:

- $Y\ (BLLs) = -27.67 + 3.8\beta_1 + 0.8\beta_2 + 7.6\beta_3$

Where: Y= blood lead level; β_1= Daily Working Hours, β_2= service years; β_3= prior employment in garage. The daily working hours, Service years and prior employment in garage predictors were positively associated with the blood lead levels and increased by one unit as the mean blood lead levels among the garage workers were increased by 3.8 µg/dl ,0.8 µg/dl and 7.6 µg/dl with a high significance difference (P< 0.05) respectively. However, the remaining predictors such as the age, lead awareness, training on OSH, safety practice, use of PPE and other predictors were not statistically significant (P>0.05) and had not direct impact on blood lead levels (Table 9).

Table 9: Effect of predictors on blood lead levels using multiple linear regression analysis among exposed groups in Addis Ababa, Ethiopia, 2023 (n=36)

Variables	Coefficient (β)	S. E	LB at 95% CI	UB at 95% CI
Constant	-27.67	12.87	-54.18	-1.15
Age in years	0.31	0.25	-0.21	0.82
Daily Working Hours	3.8*	1.38	0.96	6.63
Service years	0.8*	0.33	0.11	1.48
PPE reported (yes)	-4.17	2.9	-10.15	1.81
Lead awareness (yes)	-0.47	2.96	-6.58	5.63
Exposure prevention methods (yes)	-0.57	2.99	-6.74	5.59
Knowledge on lead hazards (yes)	-4.26	2.87	-10.17	1.66
Training on OSH (yes)	2.67	3.021	-3.56	8.89
Safety Practice (yes)	0.04	2.876	-5.88	5.96
Prior employment in garage (yes)	7.6*	3.129	1.01	13.89

*LB: lower bound; UB: upper bound; * significant at p<0.05; S.E: standard error*

6. Discussion

Regarding the socio-demographic factors, the majority of the participants in this study for both exposed and unexposed groups were men, 59 (84.3%), with 11 (15.7%) female participants. This indicated that 31 (86.1%) and 28 (82.4%) of the participants were male for the exposed and unexposed groups, respectively. Most previously conducted studies had never examined the blood lead levels of female workers in different work environments(50, 61-63). However, the study conducted in Jimma, Ethiopia, on construction workers to assess the blood lead levels, the majority of the study participants were females, with 60 (74.1%) for both exposed and unexposed groups and 21 (25.9%) of male participants(64). The possible reason for this disparity was that most people might assume that the automotive garage works only for men, and the work itself has a heavy workload. The mean age of exposed groups was 39.0±7.5 years, with a range of 27–54 years. This indicated that the mean age of our study was much greater than that of the study conducted in Lagos, Nigeria, where the mean age was 29±11 years for automobile mechanics, and the study conducted in Khyber, Pakistan, where the mean age was 32.0±10.3 years for automobile technicians(50, 65). In this study, 29 (80.6%) of the exposed groups were married. However, in previous studies that were conducted in Lagos, Nigeria, there were 64.9% and 66% of more single automobile mechanics and motor vehicles. (65, 66). With regard to educational level, only 7 (19.4%) of the exposed groups had a diploma below; however, the remaining had completed at least a diploma and above. Another study showed that in the megacity of Lagos, Nigeria, the majority (62.2%) of automobile mechanics had completed secondary education(65) .The possible explanation for this difference could be that the majority of garage workers who are engaged in garage work at the Anbessa city bus service enterprise in Ethiopia were employed based on their educational level.

With regard to occupational job positions, the majority of 15 (41.7%) of the exposed groups were engaged in mechanical occupational job positions. Similar studies were conducted in Lagos and Ibadan, Nigeria. 43% of the organized and roadside garage workers in Lagos and 68% of the Ibadan garage workers were engaged in mechanics occupational job positions (54, 67). The reason showed that for this study, the majority of the automotive work might be covered by occupational job positions for mechanics. However, in the study conducted in Jimma, Ethiopia,

on unskilled construction works, 13 (28.9%) of the painters were engaged in painters' job positions, as compared to 4 (11.1%) in the current study(64).

Regarding the addiction habits between exposed and unexposed groups, the majority of both exposed and unexposed groups were not dependable on any addiction habits in the workplace; however, 15 (41.7%) of exposed and 5 (14.7%) of unexposed groups were dependable on addiction habits such as drinking alcohol or smoking cigarettes. This results differed from the study conducted in Jimma, Ethiopia, on unskilled construction workers, alcohol consumers (20%), and daily 2 (5.2%) and occasional 5 (13.5%) cigarette smokers in a megacity in Lagos, Nigeria (64, 65). The possible explanation for this disparity might be due to the difference in sample size, poor knowledge and workload. With regard to lead awareness, 14 (38.9%) of exposed groups were not aware of lead exposure. This finding is similar to the study conducted in Lagos, Nigeria, on automobile technicians (38%) who were not aware of lead exposure but less than 89.2% who had not heard about lead exposure that was conducted in Megacity, Nigeria, on automobile mechanics (54, 65). The implication of lead exposure among garage workers might not be an immediate incident, and each garage worker did not think about the long-term effects of lead exposure. More of the exposed groups and the comparative groups had poor behavioral characteristics and utilization of PPE to prevent themselves from the entry of lead exposure to their organs. For example, half of the exposed groups and the comparative groups did not use any personal protective equipment (PPE) and did not apply the safety practices or training on OSH in the workplace as they were reported. A similar study showed that in Megacity, Lagos, Nigeria, the majority of automobile mechanics did not use safety practices or PPE(65). The reason implied that the availability of PPE by the enterprise might be late or that there might be less awareness or discomfort about safety practices during work activity

Following the increasing and expanding automotive garage workshops in Ethiopia. A few occupationally related blood lead level studies were carried out previously in Jimma town and Harar, Ethiopia, on automotive garage workers (59, 68). However, the blood lead level of the Anbessa City Bus Service Enterprise garage workers in Addis Ababa, Ethiopia, has not been studied previously. The results obtained in this study have shown that the mean blood lead level (29.7±12.2) μg/dl of exposed groups was higher than the mean blood lead level (14.8±9.9) μg/dl of unexposed groups, with a statistically significant difference ($P<0.001$). This finding is below

the study conducted in Khyber, Pakistan, on automobile technicians, the study conducted in Nearby Addis Ababa-Adama Highway on Childbearing women, and above the study conducted in Jimma, Ethiopia, on automotive garage workers with blood lead levels for both exposed and unexposed groups (65.3 ± 41.9) µg/dl and (21.7±17.6) µg/dl (P<0.001), (34.32 ± 6.39) µg/dl and (8.47 ± 3.01) µg/dl (P<0.001) and (19.7 ± 4.46) µg/dl and (10.73±2.22) µg/dl (P<0.05) respectively (35, 50, 69). The plausible explanation for this difference could be due to differences in sample size, working hours, duration of workload, poor knowledge, a lack of occupational safety training and prior employment in the garage sites, how they protect themselves from lead exposure, and the nature of the working environment in which they accomplish day-to-day occupational tasks compared to the general population.

Regarding WHO and other agencies blood lead level standards, the findings indicated that 8 (22.2%) of exposed groups blood lead levels exceeded the maximum recommended blood lead level limit (40 µg/dl) of WHO, while unexposed groups did not meet the maximum recommended blood lead levels set by the World Health Organization(70). WHO recommended that a health-based maximum individual biological action level be 40 µg/dl for male workers and 30 µg/dl for female workers. However, 34 (94.4%) of exposed and 23 (67.6%) of unexposed groups of BLLs were above the general population's BLLs recommendation limit (10 µg/dl), which was set by the WHO and the Centers for Disease Control and Prevention (CDC)(70, 71). According to OSHA and other agency standards, 26 (72.2%) of exposed and 23 (67.6%) of unexposed groups were found in acceptable ranges, whereas 2 (5.1%) of exposed and 13 (17.8%) of unexposed groups were also found in a normal range (72, 73). This indicated that OSHA and other agencies categorized the blood lead levels of adult workers in three stages: <10 µg/dl, 10-40 µg/dl and >40 µg/dl for normal, acceptable, and dangerous stage categories respectively (72, 74). However, the current OSHA maximum recommended blood lead level limit is 40 µg/dl (75). Comparing with the National Institute for Occupational Safety and Health (NIOSH) standards, 57 (81.4%) of all exposed and unexposed groups of blood lead levels exceeded the recommended standard blood lead level (5 µg/dl) (31, 32, 76). However, the average blood lead levels (29.7±12.2) µg/dl of exposed and (14.8±9.9) µg/dl of unexposed groups were less than the OSHA (40 µg/dl), the European Union Scientific Committee on Occupational Exposure (30 µg/dl), the American Conference of Governmental Industrial Hygienists (30 µg/dl), and the WHO (40 µg/dl) recommended blood lead level limits (70, 77).

This indication has shown that in Ethiopia, there are no well-known blood lead level standard limits for occupational workers since Ethiopia follows simply the WHO and ILO occupational and safety guidelines. In our study, statistical significance was not found between the occupational job positions of the exposed groups. A similar study conducted in Khyber, Pakistan, and in Jimma, Ethiopia, did not find a statistically significant difference in the occupational job positions of painters, mechanics, electricians, and welders.(50, 64). The possible explanation is that most automotive garage workers who are engaged in different occupational job positions affected with homogeneous lead exposure.

The multiple linear regression analysis showed that blood lead level (a dependent variable) was related to independent variables (daily working hours, service years, and prior employment in the garage). The results showed a statistically significant ($P<0.001$) relationship among the exposed groups with 79.8% of all combined significant independent variables on the blood lead level. Hence, regarding working time, the daily working hour factor showed that there was a significant association ($P<0.05$) with blood lead levels and increased by one unit as the mean blood lead levels among the garage workers increased by 3.8 µg/dl. A similar study reported that in Lagos, Nigeria, the level of operation time was associated and significant with the increasing blood lead level among the automobile mechanics(78). In the same way, the studies that were conducted in Jimma, Ethiopia, and Iran found that the blood lead level had a direct relationship with daily working hours (79, 80). It could be explained that the long daily working hours are an important factor to occupational lead exposure. As a result, workers who have been working in garages for long periods of time might be affected by acute and chronic health risks. For this study, the duration of work in years (service years) was also found to be an important factor in increasing the blood lead level among exposed groups. This indicated that the service years of exposed groups had positive relationships with blood lead levels. Hence, as the service years increased by one unit, the mean blood lead level of the workers also increased by 0.8 µg/dl. A similar study showed that in Lagos, Nigeria, Harar, and Jimma, Ethiopia, automotive workers with long service years had adverse health effects on lead exposure (59, 65, 68).However, in other studies conducted in Addis Ababa-Adama Highway, Ethiopia and Iran, the job experience with blood lead levels showed that lack of direct significant relationships (69, 81, 82). This difference might be due to that in sample size, workload, improper safety measures and not taking training among the workers. The other significant variable that affected the blood lead level was prior

employment at garage sites. This predictor was highly associated and increased by one unit as the mean blood lead level was increased by 7.6 µg/dl. Several studies have shown that prior employment in garage sites of workers is usually directly affected by blood lead levels compared to non-garage workers (59, 68, 78, 83, 84). The reason explained that the longer duration of work and the nature of the working environment could be contaminated with a high level of exposure to different chemical agents, especially heavy metals. As a result, most garage workers in devolving counties are currently exposed to lead and have experienced short- and long-term adverse health effects on their organs.

7. Conclusion

- Garage workers had higher significant blood lead levels as compared to the non-garage workers
- Significant number 8 (22.2%) of exposed workers blood lead levels exceeded the WHO and OSHA recommended blood lead level limit (40 µg/dl).
- Service years, daily working hours, and prior employment at garage sites had a statistically significant association on blood lead level among garage workers.

8. Strengths and Limitations

Strengths:

- The blood lead level was measured with the modern MP-AES instrument.
- The study compared two groups: garage workers and non-garage workers. This study helped to account for the fact that garage workers were more exposed to lead exposure than non-garage workers in Anbessa City Bus Service Enterprise

Limitation:

- Lack of previous similar studies in Ethiopia to compare this study.
- The study was conducted on small sample size because of resource constraints

9. Recommendation

Depending upon the findings of the study, the following recommendations were forwarded to the enterprise, workers, government, and researchers:

1. **The Enterprise:**
   - is recommended to establish hazard prevention and control strategies (OSH training, adequate PPE, personal and work-place hygiene).
   - is recommended to implement regular checkups to measure the elevation of blood lead levels among the workers.
   - Should minimize the long duration of hours to avoid the inhalation of lead dust.
2. **The workers:**
   - Should take self-responsibility to apply exposure prevention methods and try to exercise the hygiene practice to reduce the presence of lead exposures
3. **The government and other concerned bodies**
   - are recommended to prepare and implement a full biological monitoring guideline for heavy metals exposures reduction with partners.
   - Should establish health education and promote awareness for the adverse health effects of lead to the workers using the media.
4. **For further Research Studies:**
   - Nationally, longitudinal studies should conduct by the Ministry of Labor and Social Affairs and universities and institutions to show the full image of lead exposure among garage workers and other lead hazards areas by increasing the sample sizes.
   - Other studies are recommended on lead levels from dust, urine, and hair

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Annex

I. Questionnaire (English Version)

This questionnaire helps the investigator to assess the risk factors of occupational exposure to lead. Hence, respondents please help me by filling out the questionnaire correctly

PARTICIPANTS ID No.----------

Name of the Enterprise: _____Garage Location: _____

Residence area of the respondents:

1. Living City----------:
2. Sub-city: ----------
3. Woreda: ----------
4. Kebele: ----------
5. Phone No.----------

Section A: Background of Information

No.	Variables	Responses	Codes
1	Sex	Male Female	(1) (2)
2	Age of Respondents (in years) and You can Specify---------	18-25 26-35 36-45 >45	(1) (2) (3) (4)
3	Marital Status	Single Married	(1) (2)
4	Level of Education	Below Diploma Diploma Degree Above degree	(1) (2) (3) (4)
5	What is your average monthly salary from this enterprise?	<3000 3000-6000 6000-9000	(1) (2) (3)

		>9000	(4)
Section B: Occupational Health and Safety Assessment			
6	What are your current specific occupational jobs you are engaged in workplace?	Mechanics Electricians Welders Painters	(1) (2) (3) (4)
7	How long have you been worked in office (in years) ----------	1-5. 5-10 10-15 >15	(1) (2) (3) (4)
8	How many hours do you work per day in your assigned tasks? ----------	<8hrs for 8hrs 8-10hrs >10hrs	(1) (2) (3) (4)
9	Do you use proper personal protective equipment?	Yes No	(1) (2)
10	If yes for question no.9, What kind of personal protective devices do you use?	Hand gloves Eye goggles Face mask/ Mouth mask Safety shoes Apron All	(1) (2) (3) (4) (5) (6)
11	Are you aware of lead exposure as a hazard in your work?	Yes No	(1) (2)
12	What do you do to reduce your lead exposure in work place?	Washing hands before eating Changing cloths and Taking shower after the completion of tasks Taking training regularly Not used prevention methods	(1) (2) (3) (4)

13	Have you ever checked your blood lead levels?	Yes No	(1) (2)
14	If yes for question no.13, How often do you check your blood lead level?	Every six months Every year	(1) (2)
15	What kinds of bad habits do you have used without aware in work place?	Smoke cigarette Drink alcohol Chat Chewing No bad habits	(1) (2) (3) (4)
16	Do you have aware of potential chemicals hazards stored or used in workplace?	Yes No	(1) (2)
17	Have you taken occupational exposure training in the workplace?	Yes No	(1) (2)
18	Do you follow the occupational health and safety rules and regulations in workplace?	Yes No	(1) (2)
19	Are you engaged in automotive garage workshop activities previously?	Yes No	(1) (2)

Great thank you for your participation

II. Information Sheet (English Version)

Hello dear brother or sister!

My name is Merihatsidik Tesema. I am a Master of Public Health (MPH) student in the environmental and occupational health specialty program at Addis Ababa University, College of Health Sciences, School of Public Health, in Addis Ababa, Ethiopia. Currently, I am conducting my research in partial fulfillment of the Master's degree. Hence, you are invited to participate and give your blood sample voluntarily in this study.

Title of the study: Assessment of Occupational Exposure to Lead among Anbessa-Sheger City Bus Garage Workers in Addis Ababa, Ethiopia: A Comparative Cross-Sectional Study

Background of the study: From small to large automotive garage areas around the world, most garage workers are exposed to chemical exposures, especially heavy metals. At the same time, in our country, Ethiopia, workers who are mostly engaged on automotive garage sites are affected by chemical exposures. One of the most unusable chemical exposures that occurred in the automotive garage area is lead. Lead is an occupationally toxic metal that affects human health easily by entering workers' bodies through inhalation, ingestion, and skin contact. All ingestion or inhalation of lead particle can cause and affect reproductive health, memory impairment, kidney, intestinal, and lung cancer failure, central nervous system disorders, anemia, hypertension, and other conditions. As a result, the best way to identify workers with lead exposure in the workplace around the world is to test their blood lead level on a regular basis; however, in our country, Ethiopia, most workers do not test how much lead accumulates in their body organs. To identify how many workers are exposed or not exposed to lead exposure, 4-5 ml of blood will need to be collected from each participant in order to measure the blood lead level. In addition, each participant will answer self-administered structured interview questionnaires that contain demographic information about the participants, lead exposure factors, and health and safety awareness.

Objective of the Study: The objective of this study is to assess the blood lead concentration of the Anbessa City Bus Service Enterprise garage workers and exposure factors in Addis Ababa, Ethiopia.

Benefits of the study: If your blood lead level is high and outside the acceptable range during testing, you will be advised to take proper measurements (if you are voluntarily participating). The study's findings will be disseminated to your employer, enterprise, and other relevant bodies in accordance with their mandate for ensuring worker safety and health.

Risk of the study: Some participants may feel discomfort for a short time when blood is taken from their arms, but it is not a continuous feeling and is carefully manageable with trained medical laboratory professionals for the prevention of bleeding. Usually, you will think more and more about the benefits of studying than about the risk, and you can consider it an opportunity.

Rights of Participants: All participants will take part in this study voluntarily, which means that no one has the right to be forced to give blood samples. If the respondent is not voluntarily participating, he or she will have the option to continue or refuse participation at any time

Confidentiality and privacy protection: All information that is collected from the employer and respondents for this study should be confidential and coded as being honest. Participants' names are not considered a requirement for this study. The data will be secured and stored

Dissemination of the study report: The final findings of this study will be presented at Addis Ababa University School of Public Health in front of audiences. The study will also be presented as a seminar and conference discussions. Finally, the results will be given to Anbessa City Bus Service Enterprise, and then the study will be published in a peer-reviewed journal that will be accessible around the world for the scientific societies to use as a reference for further study

Contact Address: If you have any questions or suggestions for further clarification to you, you can contact the investigator directly or indirectly through phone number, email or in face to face.

Name of Investigator: Merihatsidik Tesema

Address of investigator: Addis Ababa, Ethiopia

Mobile: 0923283249

Email: tmerihatsidik@gmail.com

Name of Institute: Addis Ababa University, School of public health

Advisors E-mail:aberakumie2@yahoo.com; mobile 0911882912

Name of Advisor: Professor Abera Kumie

III. Information Sheet (Amharic version)

ሰላም ውድ ወንድሜ/እህቴ

ስሜ መርሐጽድቅ ተሰማ እባላለሁ። በአዲስ አበባ ዩኒቨርሲት ውስጥ በሚገኘው የጤና ሳይንስ ኮሌጅ በህብረተሰብ ጤና ትምህርት ክፍል የአካባቢ እና የሥራ ጤና ስፔሻሊቲ ፕሮግራም የማስተርስ ዲግሪ ተማሪ ነኝ። በአሁኑ ሰዓት እርሳስ የሚባለዉ ኬሚካል በስራ ቦታ በሰራተኞች ላይ የሚአስከትለዉን ተጽኖ ለመፈተሽ እና ለማወቅ ምርምሬን እያካሄድኩ እገኛለሁ። ስለዚህ እርስዎ በዚህ ጥናት ውስጥ እንዲሳተፉ እና የደም ናሙናዎንም በፈቃደኝነት እንዲሰጡ ተጋብዘዋል።

የጥናቱ ርዕስ፡ በአዲስ አበባ፣ ኢትዮጵያ ዉስጥ በሚገኝዉ በአንበሳ እና በሸገር የከተማ አውቶብስ *ጋራዥ* ሰራተኞች ላይ ያለውን የሊድ የሙያ ተጋላጭነት እና ተያያዝ ምክንያቶችን ማጥናት እና መመርመር።

የጥናቱ መነሻ አሳብ: በአለም ዙሪያ ከትንሽ እስከ ትልቅ በሚገኙት የመኪና *ጋራዥ* ቦታዎች አብዛኛዎቹ *ጋራጅ* ሰራተኞች ለኬሚካል አደጋዎች በተለይም ለከባድ የኬሚካል ብረቶች ይጋለጣሉ።. በአገራችን ኢትዮጵያም በተመሳሳይ ሁኔታ በአብዛኛው በአውቶሞቲቭ *ጋራዥ* ሳይቶች ላይ የተሰማሩ ሰራተኞች ለኬሚካል ተጋላጭነታቸዉ ከፍተኛ ነዉ። ስለሆነም በ*ጋራዥ* አካባቢ ከሚከሰቱት እና በጣም ከማይጠቅሙ የኬሚካል አይነት አንዱ (Lead) እርሳስ ነው። እርሳስ በመተንፈስ ፣በመጠጣት ወይንም *ጋራዝ* ዉስጥ በመብላት እና በቆዳ ንክኪ ወደ ሰራተኛው የውስጥ አካል በመግባት በቀላሉ በሰው ጤና ላይ ጉዳት የሚያደርስ መርዛማ ኬሚካል ነዉ።.ሁሉም የእርሳስ ቅንጣቶች ወደ ደማችን በመግባት የስነ ተዋልዶ ጤና ስርዓትን፣ የማስታወስ ዝግመትን፣ የኩላሊት ውድቀትን፣ የአንጀት እና የሳንባ ካንሰርን፣ የማዕከላዊ የነርቭ ሥርዓት መዛባትን፣ የደም ማነስን ፣ የደም ግፊትን ወዘተ በማስከተል የሰዉ ልጂ በየቀኑ ህይወቱን እያጣ እና ያልታ ቁራኛ እየሆነ ይገኛል በተለይ እርሳስ ለሚባል ኬሚካል የተጋለጡ ሰራተኞች ለዚህ በሽታ ተጋላጭ ናቸዉ።..ስለሆነም በአለም ላይ በእርሳስ የተጋላጡ ሰራተኞችን በስራ ቦታ በየጊዜው በመመርመር በደም ውስጥ ያለውን የእርሳስ መጠን በመለየት ተገቢዉን ክትትል እየተደረገ ሲሆን ነገር ግን በሀገራችን ኢትዮጵያ አብዛኛው ሰራተኛ በደሙ ዉስጥ ምን ያህል የእርሳስ ክምችት እንደሚከማች አይመረምርም።. ስለሆነም እርሳስ በሚባለዉ መርዛማ ኬሚካል ምን ያህል ሰራተኞች እንደተጋለጡ ወይም እንዳልተጋለጡ ለመለየት እንዲረዳ ከእያንዳንዱ ተሳታፊ ከ 4-5 ሚሊ ሊትር ደም ያስፈልጋል።.በተጨማሪም፤እያንዳንዱ ተሳታፊ ለእርሳስ ሊአጋልጡ የሚችሉ ምክንያቶችንም አብሮ መናገር ይችላል።

የጥናቱ ዓላማ: የዚህ ጥናት ዋና አላማ በአዲስ አበባ ኢትዮጵያ ዉስጥ በአንበሳ እና በሸገር የከተማ አውቶብስ *ጋራዥ* ሰራተኞች ላይ እርሳስ የሚባለዉ የኬሚካል አይነት በደማቸዉ ዉስጥ ከሚገባዉ በላይ መኖሩን ማረጋገጥ እና ተያያዥ ምክንያቶችን ማወቅ ነዉ።

የዚህ ጥናት ዋና ጥቅሞች: በምርመራ ወቅት የደምዎ ደረጃ ከፍ ያለ ከሆነ እና ከሚፈለገዉ በላይ ከሆነ፤ ትክክለኛውን መከላከያ እርምጃዎችን እንዲወስዱ ይመከራሉ ወይንም በፈቃደኝነት ላይ የተመሰረተ የህክምና ክትትል እንዲአደርጉ በሥራ እና ክህሎት ሚኒስቴር በኩል ሁኔታዎች እሚመቻችበት አጋጣሚ ይፈጠርለወታል ፤ የጥናቱ የመጨረሻ ውጤት የሰራተኞችን ደህንነት እና ጤና ለመጠበቅ በተሰጣቸው ስልጣን መሰረት ለአሰሪዎ እና ለሚመለከታቸዉ አጋር ድርጅቶች ይሰራጫል።

የጥናቱ ተጽኖ/ስጋት: ደም ከእጅ ሲወሰድ በአንዳድ ተሳታፊዎች ላይ ለአጭር ጊዜ የሚቆይ ምቾት ላይሰማዎት ይችል ይሆናል ነገር ግን ደም እሚቀዳለዎት በሰለጠኑ የሕክምና ላብራቶሪ ባለሙያዎች ሲሆን ደም ሲወሰድልዎት በርስዎ ላይ ምንም ዓይነት የጎንዮሽ ጉዳት እንደማያርስዎበት ላረጋግጥልዎት እወዳለሁ፤ ብዙውን ጊዜ ደግሞ እርስዎት ማሰብ ያለብዎት ስለጥናቱ ጥቅም እንጂ ሌላ ተያያዥ ጉዳት እንደሌለዉ ማወቅ አለብዎት ።

የተሳታፊዎች መብቶች፡ ሁሉም ተሳታፊዎች በዚህ ጥናት ውስጥ በፈቃደኝነት ይሳተፉ ማለት ማንም ሰው ያለተሳታፊዉ ፈቃድ የደም ናሙና እንዲሰጥ የማስገደድ መብት የለውም ማለት ነው.።ተሳታፊዎቹ ማለትም እሱ/ሷ በፈቃደኝነት ካልሆነ በስተቀር በዚህ ጥናት ላይ በማንኛውም ጊዜ መሳተፍ ወይንም አለመሳተፍ ይችላሉ።

ምስጢራዊነት እና የግላዊነት ጥበቃ: ለዚህ ጥናት ከአሰሪ እና ምላሽ ሰጪዎች የሚሰበሰበው መረጃ ሁሉ ሚስጥራዊ እና ታማኝ በሆነ ኮድ ይያዛል. የተሳታፊዎች ስም ደግሞ ለዚህ ጥናት እንደ መስፈርት ሁኖ አይቆጠርም። የተሰበሰበዉ መረጃ የሚቀመጠዉ በሚስጢር ሁኖ በአጥኝዉ ብቻ ነዉ።

የተገኘዉን ጥናት ማሰራጨት፡የዚህ ጥናት የመጨረሻ ውጤት በአዲስ አበባ ዩኒቨርሲቲ የህብረተሰብ ጤና ትምህርት ቤት ብዙ ታዳሚዎች ባሉበት ይቀርባል።ጥናቱም በመንግስታዊ እና መንግስታዊ ባልሆኑ ድርጅቶች ሴሚናሮች እና ኮንፈረንሶች ለውይይት ይቀርባል። በመጨረሻም የጥናቱ የመጨረሻ ዉጤት ለአንበሳ የከተማ አውቶቡስ ኢንተርፕራይዝ ይነገራቸዋል ከዚያም በአቻ ግምገማ ጆርናል ላይ ታትሞ ለሳይንሳዊ ማኅበራት በአውቶሞቲቭ ጋራዥ ሠራተኞች ላይ ለቀጣይ ጥናት ዋቢ ሆኖ እንዲያገለግል ይደረጋል።

ጥናቱን የሚአጠናዉ ስም: መርሐጽድቅ ተሰማ አበበ

የአጥኝዉ አድሬስ: አዲስ አበባ፣ኢትዮጵያ

ስልክ ቁጥር:0923283249

email: tmerihatsidik@gmail.com

ጥናቱ የሚካሄድበት ኢንስቲትዩት ስም:አዲስ አበባ ዩኒቨርሲቲ የህብረተሰብ ጤና ትምህርት ቤት

Advisors E-mail:aberakumie2@yahoo.com; mobile 091188291

Name of Advisor: Professor Abera Kumie

IV. Informed consent (English Version)

I have read and accept this information based on all of the above-written words and meaning-filled sentences to test my health status on occupational lead exposure, I am interested to provide my blood sample for this study without any outside pressure**.** Hence, I would like to declare voluntarily by putting my signature on two copies of this informed consent form, returning one copy to the investigator, and keeping the other with me as a document.

Investigator: **Participants:**

Name: _____ **Name: _____**

Sign: _____ **Sign: _____**

Date: _____ **Date: _____**

For Investigator use

Name of data collector: _____ Sign: _____

Date of sample collection: _____ Time started: _____ Time completed: _____

Result of Respondents in data collection:

A. Completed
B. Partially completed
C. Refused
D. Not available to respond

Checked By

Supervisor name……. Signature…… Date…….

Great thank you for voluntarily participation on this study!!!

V. Informed Consent (Amharic version)

እኔ በዚህ በስራ ቦታ እርሳስ ለሚባለዉ ኬሚካል መጋለጥ ላይ ያለኝን የጤና ሁኔታን ለመፈተሽ እና ለማወቅ ከላይ በተጠቀሱት ሁሉም የጽሁፍ ቃላት እና ሙሉ ዓረፍተ ነገሮች ላይ በሚገባ በማንበብ ተረድቻለሁ፣ ስለዚህ ምንም አይነት የውጭ ተጽኖ ሳይደረግብኝ በዚህ ጥናት ላይ የደም ናሙናዬን ለመስጠት ፍላጎት አለኝ።ስለሆነም ፊርማዬን በዚህ በመረጃ በተደገፈ የፈቃድ ቅጽ ላይ በሁለት ቅጂዎች ላይ በፈቃደኝነት በማስቀመጥ እና አንዱን ቅጂ ወደ ተመራማሪዉ በመመለስ ሁለተኛውን ቅጂ ደግሞ ከእኔ ጋ በማስቀመጥ ከዚህ በታች ባለዉ ፊርማየ አረጋግጣለሁ።

ተመራማሪዉ: **መልስ ሰጭ(ተሳታፊ):**

ስም: _____ **ስም:** _____

ፊርማ: _____ **ፊርማ:** _____

ቀን: _____ **ቀን:** _____

በዚህ ጥናት ላይ በፈቃደኝነት ስለተሳተፉ በጣም እናመሰግናለን!!!

VI. Laboratory Results of blood lead levels for each exposed and unexposed group

Lab. results for exposed groups

S. N	BLL (µg/dl)	Sex	Age (in Years)	Occupational Job position	Work experience (in Years)	Codes of the Participants
1	30.00	Male	43.00	Mechanics	16.00	GM-01
2	25.00	Female	36.00	Mechanics	12.00	GM-02
3	52.50	Male	49.00	Mechanics	25.00	GM-03
4	45.00	Male	45.00	Mechanics	15.00	GM-04
5	22.50	Female	36.00	Mechanics	10.00	GM-05
6	10.00	Female	31.00	Mechanics	7.00	GM-06
7	25.00	Male	37.00	Electrician	6.00	GE-07
8	17.50	Male	27.00	Welder	7.00	GW-08
9	12.50	Male	35.00	Welder	9.00	GW-09
10	20.00	Male	38.00	Welder	6.00	GW-10
11	27.50	Male	45.00	Painter	16.00	GP-11
12	27.50	Male	40.00	Mechanics	14.00	JM-12
13	27.50	Male	30.00	Mechanics	5.00	JM-13
14	32.50	Male	45.00	Mechanics	14.00	JM-14
15	41.00	Male	47.00	Electrician	16.00	JE-15
16	6.00	Male	30.00	Welder	5.00	JW-16
17	25.00	Male	30.00	Welder	7.00	JW-17
18	27.50	Male	31.00	Welder	6.00	JW-18
19	32.50	Male	48.00	Painter	18.00	JP-19
20	35.00	Female	45.00	Mechanics	17.00	KM-20
21	37.50	Male	44.00	Mechanics	14.00	KM-21
22	27.50	Female	30.00	Mechanics	10.00	KM-22
23	35.00	Male	46.00	Electrician	16.00	KE-23
24	50.00	Male	41.00	Electrician	21.00	KE-24
25	22.50	Male	31.00	Electrician	11.00	KE-25
26	25.00	Male	35.00	Welder	12.00	KW-26
27	30.00	Male	49.00	Welder	17.00	KW-27
28	35.00	Male	42.00	Painter	14.00	KP-28
29	47.00	Male	47.00	Painter	18.00	KP-29
30	50.00	Male	54.00	Mechanics	18.00	SM-30
31	13.25	Male	29.00	Mechanics	7.00	SM-31
32	22.50	Male	30.00	Mechanics	7.00	SM-32
33	47.50	Male	45.00	Electrician	14.00	SE-33
34	7.50	Male	29.00	Electrician	7.00	SE-34
35	35.00	Male	44.00	Welder	22.00	SW-35
36	42.50	Male	40.00	Welder	20.00	SW-36

Lab. results for unexposed groups

S. N	BLL (µg/dl)	Sex	Age (In years	Occupational Job position	Work experience (in Years)	Codes of the Participants
1	23.00	Male	49.00	Supportive Staffs	19.00	WO -01
2	BDL	Male	38.00	Supportive Staffs	10.00	WO-02
3	32.50	Male	49.00	Supportive Staffs	20.00	WO-03
4	17.50	Male	39.00	Health Professional	16.00	WO-04
5	15.00	Male	45.00	Health Professional	13.00	WO-05
6	BDL	Male	39.00	Health Professional	8.00	WO-06
7	3.00	Male	28.00	Supportive Staffs	6.00	WO-07
8	BDL	Female	35.00	Supportive Staffs	5.00	WO-08
9	22.50	Female	43.00	Supportive Staffs	10.00	WO-09
10	17.00	Female	42.00	Supportive Staffs	13.00	WO-10
11	5.00	Female	44.00	Supportive Staffs	11.00	WO-11
12	7.50	Male	29.00	Health Professional	6.00	WO-12
13	5.00	Male	28.00	Health Professional	8.00	WO-13
14	15.00	Male	39.00	Supportive Staffs	9.00	WO-14
15	30.00	Male	45.00	Health Professional	16.00	WO-15
16	20.00	Male	34.00	Health Professional	8.00	WO-16
17	28.00	Male	38.00	Health Professional	16.00	WO-17
18	15.00	Male	40.00	Health Professional	13.00	WO-18
19	10.00	Male	38.00	Health Professional	6.00	WO-19
20	10.00	Male	37.00	Health Professional	10.00	WO-20
21	13.00	Female	40.00	Supportive Staffs	11.00	WO-21
22	25.00	Male	36.00	Health Professional	9.00	WO-22
23	17.50	Female	46.00	Health Professional	15.00	WO-23
24	18.00	Male	46.00	Supportive Staffs	17.00	WO-24
25	30.00	Male	37.00	Health Professional	18.00	WO-25
26	25.00	Male	35.00	Health Professional	14.00	WO-26
27	8.00	Male	33.00	Health Professional	13.00	WO-27
28	23.00	Male	43.00	Health Professional	15.00	WO-28
29	18.00	Male	30.00	Health Professional	6.00	WO-29
30	13.00	Male	31.00	Health Professional	17.00	WO-30
31	5.00	Male	32.00	Health Professional	13.00	WO-31
32	3.00	Male	30.00	Health Professional	5.00	WO-32
33	BDL	Male	29.00	Health Professional	8.00	WO-33
34	30.00	Male	43.00	Health Professional	17.00	WO-34

Photographic Images for lead analysis

Study area at Shegole garage site

Sample collection at kality garage site

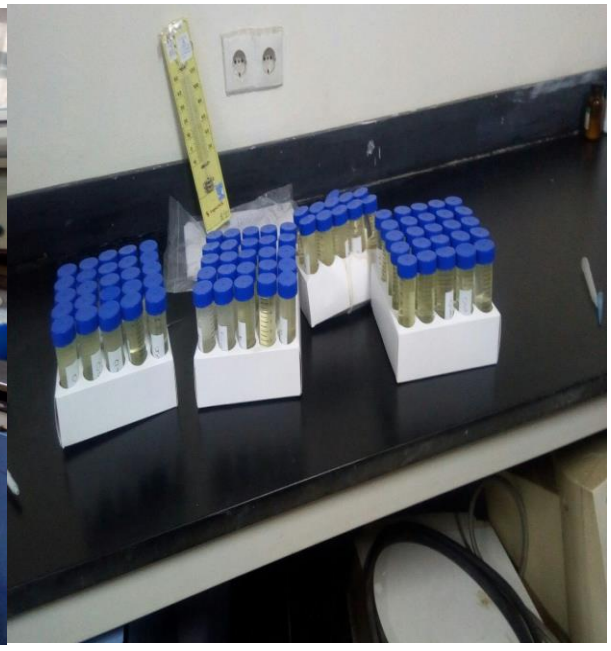
Sample collection at Gerji garage site esite

Sample collection at Shegole garage

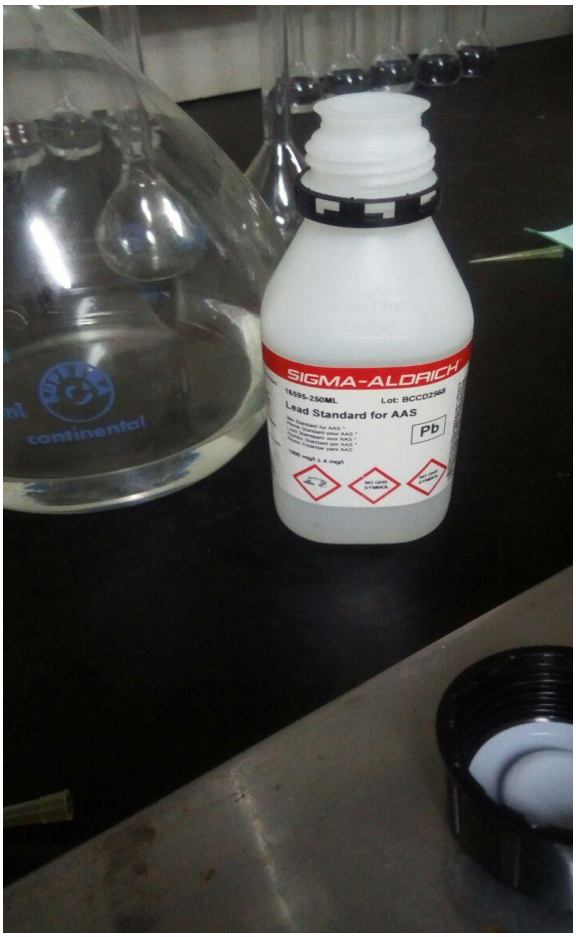
collection of samples from EPHI

Laboratory equipment Arrangement

Sample preparation and digestion



Samples ready for MP-AES reading



1000 mg/L lead standard solution

Clear sample solutions after digestion

The Jemo/Mekanissa garage site workshop

MP-AES instrument of the EPHI Laboratory

MP-AES instrument of FDA Laboratory

Declaration

I, the undersigned declare that this thesis is my original work in partial fulfillment of the requirement for the degree of Masters of Public health in Environmental and Occupational Health specialty. I also declare that it has never been presented in this or any other University and that all resources and materials used in the thesis have been duly acknowledged.

Name of the student: Merihatsidik Tesema

Signature: ---------- Date: ----------

Name of the Institute to be summited the thesis: Addis Ababa University, School of Public Health

This thesis has been submitted for examination with my approval as University Advisors

Name of principal advisor: Abera Kumie (PhD.)

Signature: ---------- Date: ----------

Name of Co-advisor: Samson Wakuma (PhD.)

Signature: ----------Date:----------