KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI, GHANA

COLLEGE OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

EXPOSURE OF AUTOMOBILE TECHNICIANS TO LEAD (Pb) AND SELF REPORTED HEALTH SYMPTOMS AMONG MALE ADULTS IN THE SUNYANI MUNICIPAL MAGAZINE

BY

LUKE VISSER DONYINA

NOVEMBER 2019

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Luke Visser Donyina (BSc. Public Health)

A THESIS SUBMITTED TO THE SCHOOL OF PUBLIC HEALTH, COLLEGE OF HEALTH SCIENCES, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

AWARD OF A MASTER’S DEGREE IN ENVIRONMENT AND PUBLIC HEALTH

NOVEMBER, 2019

DECLARATION

I Luke Visser Donyina hereby do declare that except for references to other people‘s work which have been duly acknowledged, this piece of work is my own composition and neither in whole nor in part has this work been presented for the award of a degree in this university or elsewhere.

Luke Visser Donyina ………………………… …………………..

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(Head of Department) Signature Date

ABSTRACT

Background: Lead (Pb) is found naturally at diminutive levels in earth crust, largely as lead sulfide. However, as an industrial metal its presence in the environment could largely be attributed to anthropogenic activities. Lead (Pb) exposure account for 143000 deaths annually and 0.6% of the global burden of disease. Lead (Pb) intoxication occurs when people who directly or indirectly interact with the metal (lead) are exposed to inorganic lead (Pb) chemical or other materials that may habour lead (Pb) as its component.

Method: A cross-sectional study was conducted from May to December 2017 among male adults between age 18 and 60 years old working in the Sunyani Municipal Magazine. 200 respondents were randomly selected from the garages association register. Data was collected using well-structured questionnaire containing both open and close-ended questions whereas urine sample were collected using acid-washed, decontaminated 20ml polyethylene containers and sent to Ghana Standard Authority for the analysis. Descriptive statistics as well as tests for associations using Chi square and multiple logistic regression were conducted between the outcome and independent variables

Results: The mean urine lead level in all 200 respondents was 3.78µg/L with a standard deviation of 3.12µg/L. However, Radiator repairers (5.28µg/L) recorded the highest urine lead level, followed by Battery charging specialist (4.96µg/L), Spray painters (4.44µg/L) and then Mechanics (3.53µg/L). Auto-electricians recorded the least mean urine lead level of 1.94µg/L. There was association between urine Pb level and self-reported health symptoms of respondents. The mean urine lead level among respondents who reported to have hypertension, Chest pains, Heart palpitation, Low libido, Reduced sperm count, Anemia, Headache, Dullness, Muscular tremor, Loss of memory, poor attention span, Irritability, Stuff nose rhinitis, chest tightness and wheezing had significantly higher compared to the mean urine lead levels of those who did not have such symptoms (p-values <0.05)

Conclusion: Findings from this study have revealed that occupational factors, awareness of Pb hazards, practice of personal hygiene and lifestyle factors were the major factors that put automobile technician at risk of Pb exposure hence there is the need for various control measures such as training and health education as fundamental means in the prevention of lead exposures in automobile technicians.

DEDICATION

This Thesis is dedicated to my daughter, Christodia Nana Akosua Akwabea who has been a blessing unto my life.

It is also dedicated to my mother, Kate Adu-Donyina whose maternal role and financial contribution has been more than enough to bring me this far. Mum I will forever be grateful.

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LIST OF ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
BLL	Blood Lead Level
BMD	Bone Mineral Density
CDC	Center for Disease Control
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
IARC	International Agency for Research on Cancer
ILO	International Labor Organization
IPCS	International Programme on Chemical Safety
MDGs	Millennium Development Goals
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
Pb	Lead
U-Pb	Urine Lead
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Lead (Pb) is found naturally at diminutive levels in earth crust, largely as lead sulfide. However, as an industrial metal its presence in the environment could largely be attributed to human activities, such as; mining, smelting, refined and used in producing of diverse products such as paints, batteries, lining for pipes, shielding from radiations and as anti-knocking and binding agents in gasoline (leaded petrol) (Florea, 2006). Most countries however, have legislation that prevents lead (Pb) from being used as an anti-knocking additive, hence the term ―unleaded petrol‖ (WHO, 2010). Despite its use, lead (Pb) is also highly toxic and has caused a number of public health epidemics dating back nearly 2500 years ago. Pliny the elder (as far back as A.D 23-79) recorded that workers who painted ships with naïve ceruse protected their face with loose bags to avoid breathing of noxious dust generating from lead. In 370 B.C. Hippocrates also attributed a severe case of colic in a worker who extracted metals to lead due to its exposure (Bamisayo Oluwagbemi, 2007).

Humans engage in different occupations with the primary goal of earning a living. These occupations may be in diverse forms which range from skilled, semi-skilled, to un-skilled occupations (Muhammad, 2014). In Africa and Asia majority of people could be categorized under the semi-skilled category. The apprentices are taking through the training while the work is also done concurrently with the help of the employer. Most of the people under the semi-skilled category are either illiterate or semi-literate with some having little or no formal education (Muhammad, 2014). Examples of occupations under this category are; painters, welders, smelters, auto mechanics and so forth (Abdulsalam *et al.*, 2015). In a developing continent like Africa more than half (70%)

of the employment may be in the informal sector with (10 – 60) percent contribution to the gross domestic production GDP (ILO, 2002).

The International Labour Organization has nearly 35 metals which are of key concern with regards to occupational/work exposure. If not properly handled two thirds of these metals can cause health hazards and may cause definite lethal effects in humans (ILO, 2005). A number of metals are not toxic in little quantities and may, on the other hand, be vital for good health. However, some metals, even in little doses, may lead to both abrupt and chronic poisoning (Muhammad, 2014). In 2004 lead exposure was estimated to have accounted 143,000 deaths 0.6% of the global burden of disease, with the highest burden in developing regions (WHO, 2009).Damage due to lead (Pb) intoxication may involve imbalance in the blood composition or nervous system, or injury to the kidneys or liver (Muhammad, 2014). Kidney damage occurs when there is a high exposure level of lead (Pb) (Grant, 2009). However, research shows that even in minute levels, the damage can still occur. According to the International Agency for Research on Cancer (IARC), lead (Pb) is considered to have carcinogenic properties and hence it can advance the risk of lung, stomach and bladder cancer (IARC, 2004).

Human activities like mining, refining, smelting and recycling of lead have resulted in the presence of lead in the environment (ILO, 2011). Unlike other metals like iron and zinc, there is no known physiological role of lead (Pb) in the human body, so there is no threshold level which can be considered as nontoxic (WHO, 2010 and IPCS, 1995). Occupational lead exposure is considered as a major source of lead poisoning in adults (Staudinger & Roth. 1998). Parts of lead found in the human body due to inhalation of contaminated air or direct ingestion is absorbed and spread to different part of the human body, from where it can be excreted only in certain conditions and certain quantities (Lead, 2001). Throughout a lifetime, the lead in the human body (regardless of the route of entry) is distributed between the bloodstream and bones and between blood and soft tissues (WHO, 2010). When one is exposed to lead, there are various factors that will determine toxicity. These factors include but not limited to; the dose (how much), the duration (how long), and route of exposure (Nowak and Chmielnicka, 2000). Other vital factors that are considered are other chemicals you are exposed to, your age, sex, diet, family traits, lifestyle, and state of health (ATSDR, 2007).

In measuring the total lead (Pb) levels in humans, the main lead exposure biomarkers used are; tissues or body fluids such as blood and urine or bone and hair. Lead (Pb) levels could also be determined by measuring the biological responses to lead (Pb) exposure. Among these known biomarkers, blood lead levels (BLL) is the most frequently used because the level of lead in the blood is closely associated to the degree of the adverse health effects inflicted by the exposure (Sanders *et al*., 2009). The exposure to lead put automobile technicians and other related occupational groups at risk of some health hazards that manifests with non-specific health symptoms like; irritability, stomach ache, diarrhoea, colic, distractibility and lethargy
(Gwazda Roberto, Campbell Carla, Donald Smith, 2005). According to World Health Organization the yearly non-fatal work - related diseases caused by exposure to hazards and hazardous conditions at the place of work stand at 160 million out of the 2.8 billion global workforces (Enander *et al*., 2004). In 2016, it reported that the global health effects of lead following exposure resulted in 540,000 deaths and 13.9 million years of health life lost (DALYs) (IHME, 2016). The highest burden of this was developing countries where IHME estimated that; lead exposure accounted for
63.8% of the global burden of idiopathic developmental intellectual disability, 3% of the global burden of ischaemic heart disease and 3.1% of the global burden of stroke (IHME, 2016).Lead (Pb) intoxication occurs when people who directly or indirectly

interact with the metal (lead) are exposed to inorganic lead (Pb) chemical or other materials that may habour lead (Pb) as its component (ILO, 2002).

Today, people may get exposed to this toxic metal through pathways which include but not limited to leaded fuel and paints, environmental exposure, contact with lead contaminated waste, and occupational exposures (Omokhodion, 1999). Occupational lead exposure occurs through inhalation of air that is contaminated with lead (Pb) particles and by direct ingestion of lead (Pb) in food/water (Gwazda, 2005). Other known source of lead (Pb) exposure is the environmental emissions containing lead (Pb) (Fewtrell *et al*., 2014). Lead (Pb) can be conveyed and spread from fixed, mobile, and natural sources primarily via air. Majority of emissions coming from lead get settled close to the source although some particulate matter (< l2mm) in diameter find its way over far distances and cause contamination of remote sites (Kinder, 1997).

1.2 Statement of Research Problem

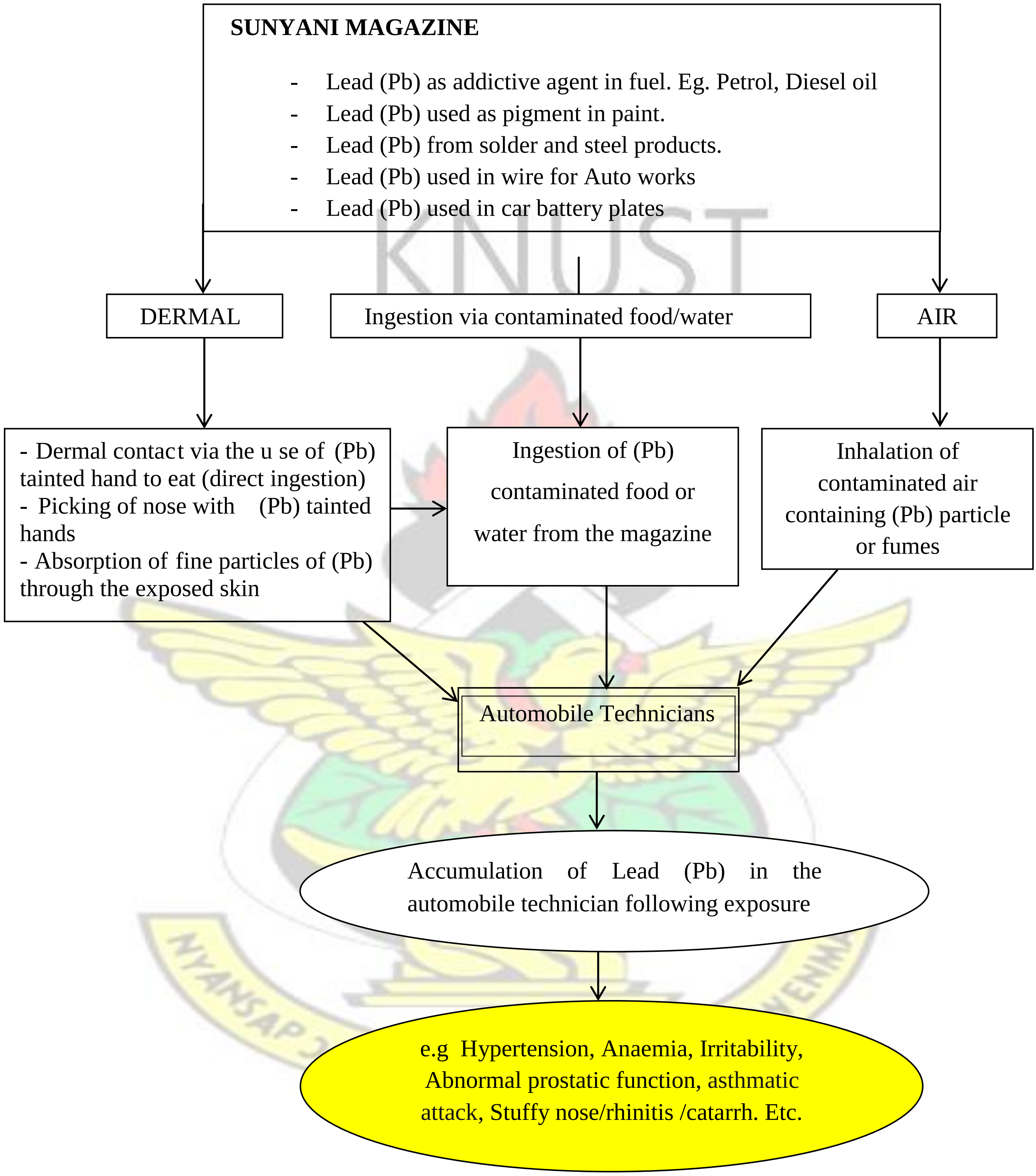
Exposure to lead (Pb) at the workplace is of public health importance especially in developing countries where there is little awareness and education on the hazardous nature of this metal following exposure is relatively low(Muhammad, 2014). According to a research by the WHO, 98% of adults and 99% of children living in low and middle-income countries are affected by lead exposure (WHO, 2009). There are a number of serious exposures of workers in artisan professions to lead (Pb). Spray painters, radiator repairers, battery repairers, welders and repair works executed by mechanics have been reported to be exposed to lead (Pb) (Abdulsalam *et al.*, 2015).

Numerous activities which involve the use of lead (Pb) and its product are carried out by automobile technicians. These workers are exposed to lead (Pb) by the virtue of their occupation which is also an integral part of their lives since survival is greatly dependent on them (Muhammad, 2014). No matter how minute the fraction of lead (Pb), it poses a threat at the workplace. It has become apparently dangerous considering that most people engage in such occupations for a substantial part of their lives and spend more than 8 hours each day at work with low or no adherence to occupational health and safety practices usually in poor and developing countries (Monney *et al*., 2014). Automobile technicians are exposed to lead (Pb) from solder fumes and dust. Lead (Pb) could pose serious health problems over a long period and the low level adherence to safety measures at work due to ignorance and poverty even magnifies the problem (Abdulsalam *et al.*, 2015).

A major objective of occupational health is how workers are protected in their working environment from hazards resulting from factors that have adverse effects on health. There is little supervision among majority of working population in developing countries in terms of the risk that they are exposed to (WHO, 1994). In Ghana, ensuring healthy and safe working environment for workers as well as the use of good work ethics rest on the shoulders of the Department of Factories Inspectorate (Adei *et al*., 2011). The department lacks a broad national surveillance for occupational injuries and illness and most of their activities are also skewed towards the formal sector at the expense of the informal sector (Ametepeh, 2011). The majority of Ghana‘s labor force can be found in the informal sector and with this, only 2% have OSH services (Dwumfour and Asiedu, 2013).

There are numerous studies to show that some automobile technicians do not adhere to best available engineering control technologies and often fail to adequately protect themselves from potential workplace exposures (Duressa, 2008). However these automobile technicians are in constant contact with lead (Pb) due to their occupation apart from general environmental exposures (Ayoola, 1979). Consequently, they deserve special monitoring in this regards. With a lot of researches conducted on different occupation to assess hazards and exposure, there are little studies in Ghana on occupational lead (Pb) exposure among automobile technicians. Moreover majority of all the conducted studies on occupational exposure to lead (Pb) have focused on measuring the blood/environmental lead levels and determining whether or not the levels obtained fall within acceptable limits, and hence this study focused on identifying the risk factors that predispose automobile technicians to lead fumes or dust at the workplace via urine analysis.

Figure 1.1: Conceptual Framework



Source: Author‘s construct, 2019 Figure 1 above illustrates how automobile technicians are exposed to lead from the various sources at the work place, the pathways of exposure and adverse health effects of Pb following exposure. It also shows how other factors (confounders) could also account for these health symptoms.

Lead (Pb) at the magazine emanating from the various sources enters the environment due the quantity of lead content in the materials used at the workshops. Basically, lead exposure in the general sense (Automobile technicians inclusive) occurs mainly through direct ingestion, making it the leading route via which lead is accumulation and elevated in the body upon ingestion. Ingestion of contaminated, water, alcohol or a hand-to-mouth activity using contaminated hands is significant for occupationally exposed individuals. The amount of lead absorbed into the body following ingestion is about 20% to 70% (ATSDR, 2010).The second significant pathway of lead exposure for automobile technicians is through inhalation of lead contaminated air. The amount of lead absorbed through the respiratory system is dependent on certain factors like; particle size, respiratory volume, amount of deposition and the mucociliary clearance of the inhaled lead. Once exposure occurs through respiratory system, nearly all the inhaled lead is absorbed into the body (ATSDR, 2010).

The third pathway is through the dermal absorption. Dermal absorption is common occupationally exposed individuals who work with lead or materials containing lead. In certain instances very fine particles of (Pb) may falls on the naked skin and get absorbed through the skin pores. As a cumulative toxicant, (Pb) gets accumulated in the automobile technicians who get exposed to it. The accumulation of (Pb) in different areas of the human body following exposure may compromise the health of the automobile technicians leading to a disease sate and even death in certain instances where the Pb-levels become exceedingly high (ATSDR, 2010)

1.4 Justification

There are a lot of research reports that shows the correlation between exposure to lead (Pb) and known health condition as well as reports on serious exposure of workers in artisan profession to lead (Pb). Spray painters, panel beating, metal cutting, radiator repairers, battery repairers, and welders as well as repair works by mechanics have been reported to be exposed to lead (Abdulsalam *et al*., 2015).

The petroleum amendment regulation, 2003 (LI 1732) was passed to ban the production and importation of leaded petrol in Ghana but there is little assurance that leaded petrol has totally been eliminated from Ghana. Petrol and petroleum products with Pb components may still be utilize by technicians in their daily activities hence, the exposure to lead (Pb) at the workplace pose as a threat to public health issue.
(Graphic auto matter, 2013). The Occupational Health and Safety unit under the Ghana Health Service do not have a standard for lead to serve as a threshold value for workers who are occupationally exposed. There seems to be little public awareness on Pb intoxication and several medical conditions that could result from Pb intoxication are largely misdiagnosed or mismanaged (Tong *et al.*, 2000). Lack of many laboratories capacity to assess the level of lead (Pb) in humans contribute to making the estimate of the health burden of lead (Pb) poisoning difficult to ascertain (US DHHS, 2000). Identifying the risk factors that predispose automobile technicians to lead is the main focus of the study. Poor statistics available on the lead (Pb) levels of automobiles technicians in Ghana does not clearly depict the current problem on the job, also making awareness about the problem low or nonexistent. Ghana, just as most other developing African countries lacks accurate and up to date statistical figures on occupational exposure to lead (Pb) therefore the need to provide such statistics to facilitate analyses

on occupational health in Ghana which is intended to affect the formulation and amendments of occupational policies.

1.5 Objectives of the Study

1.5.1 Main objective:

To identify the risk factors that predisposes automobile technicians in the Sunyani Magazine in the Brong Ahafo Region of Ghana to lead (Pb).

1.5.2 Specific objectives:

1. To determine the urine lead (Pb) levels of automobile technicians in the Magazine
2. To compare the measured urine lead (Pb) levels of automobile technicians in various job specialty.
3. To evaluate the association between self-reported health symptoms and lead (Pb) levels.

1.6 Research Questions

1. What are the urine lead (Pb) levels among automobile technicians in Sunyani Magazine?
2. What is the urine lead (Pb) level among automobile technicians in the various job specialties?
3. Is there an association between levels of lead (Pb) and the self-reported health symptoms?

1.7 Significance of the Study

A study of the urine lead levels of the automobile technicians in the Sunyani Magazine has the potential of providing an insight into the exposure levels and the health problems of these technicians. The results from this study could be used as baseline data to draw inferences about similar, but unmeasured areas or to establish a trend and also by the government and other stakeholders in taking decisions and making policies with respect to occupational health issues.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The focus of literature review is to summarize, support, or criticize the works of other authors. For these reasons, this chapter delves into existing literature on; Automobile technicians, Types of Hazard experienced by automobile technicians, History of Lead Toxicity, Occupational Health and Workplace Hazards, Occupational Health and Exposure to Lead in Developing Countries, Lead in the Workplace, Risk Factors to Lead Exposure, Factors that Influence the Levels of Lead in Automobile Technicians, Effect of Lead on Humans, use of Biomakers to Detect and Quantify Lead Exposure and Management of Lead Poisoning.

2.2 Automobile Technicians

Automobile technicians /mechanics are a category of entrepreneurs and apprentices involved in repair of motor vehicles, maintenance, refurbishing, and all other vehicle related works. The apprentices are the main workforce in this industry, usually working in small to medium workshops. The technicians includes; auto electricians, spray painters, brake repairers, radiator repairers, welders, battery chargers/repair, general mechanic etc. who are commonly found working in the same area or close to each other. Automobile technicians are located in specific areas or along the roadside where they find jobs. They offer quick and instant repairs services to vehicle owners and drivers. Their charges are relatively low comparatively to technicians in wellorganized garages or workshops found in the formal sector and hence, this helps the technicians attracting a lot of customers for service as well an increase exposure to hazards in their working environment (Richard Amfo-Otu and Jackson Kwabena
Agyemang, 2016).

Spray painter are a group of technicians who use fillers and sprays of different colours to vehicles following some repairing damages or just after applying new colour to motor vehicles. Auto electricians deal in the use of minor and general re-wiring of vehicles which include electrical work on lighting system, sensors, fuses, control board general auto and sound electrical. Radiator repairers work and maintain damages on water tanks and condensers, battery chargers/ repairers re-charge and refill batteries, repairs damaged ones by replacing the battery plates found in them.

Welders and panel's beaters use steel, cathode rod, irons and other metals in working. General mechanic works involve the repair of engines, gear-box, steer rags, etc and other general refurbish and maintenance work (Richard Amfo-Otu and Jackson Kwabena Agyemang, 2016).

2.3 Types of Hazards at the Workplace

Occupational hazards among technicians in the informal sector could be categorized as physical, biological, chemical and agronomical. Physical hazards automobile technicians are exposed to include cuts, bruises, noise, smoke and burns. Chemicals hazards include; chemicals such as gasoline, benzene, asbestos, lead, mercury and exhaust fumes. Bites from snakes and insects duet poor working environment are some of the biological hazards automobile technicians face. Ergonomically, hazards faced by automobile technicians include; awkward working postures, lifting of heavy vehicles parts like the engine blocks and the gear-box, and skeletal trauma (Amfo-Otu and Agyemang, 2016; Schwartz, 1987).

Occupational lead exposure occurs in many jobs and in the environment. In recent times, lead has resulted in many occupational diseases with between 0.5 and 1.5 million workers being exposed to lead in the workplace. Lead (Pb) accounts for 0.6% of the global burden of disease (WHO, 2013).

2.4 Occupational Safety and Health Regulations

Automobile technicians execute their work in an organized or roadside setting with diverse level of exposure to occupational hazards including lead due to the nature of their work. There seems to be limited knowledge and experience on issues related to occupational safety and health among automobile technicians particularly those in the informal sectors (Elias, Ijaduola, and Sofola, 2003). However, the labor force in organize garages are more likely to be supervised by regulatory officials, follow all known occupational health and safety protocols and report occupational accidents and diseases (Awoyemi, 2002). Workers could also be motivated to encourage safety practices among workers. The case among workers in the informal sector is quite different since a study on lead exposure among automobile radiator repair workers and their children in the New York City revealed that none of the workers screened had been taken through health and safety training and protocols concerning occupational Pb exposure. The roadside technicians in Nigeria and some other small scale industries are not regulated by legislation or government policies (WHO/ILO 1995).

2.4.1 Occupational Health and Workplace Hazards

Due to the common disorder of occupational exposure to lead and the subsequent deaths that followed in 1882, there was a parliamentary inquiry into working conditions in the United Kingdom. This initiative motivated the introduction of the Factory and Workshop Act in 1883(Prevention of Lead Poisoning), which demanded that all lead factories to operate within some minimal standards, and example of which is the creation of ventilated environment and provision of protective clothing

(Hunter, 1978, Smith, 1984, Winder, 1984).

There has been a global attempt to deliberately protect personnel from work-related injuries and illness which has been a huge issue of enormous concern affecting workers, the government, and the entire public. This issue has gain the necessary attention because working in a safe and injury free environment positively affects productivity through the enhancement of the physical, mental, and social well-being of workers. Furthermore protecting workers also avoids payment of medical bills, compensation, work disruption, loss of skilled staff and others that may come from accident during working. (Hughes and Phil, 2007, Tadesse and Admassu, 2006). According to the ILO, the annual world record of work-related accidents stands at approximately 270 million, with a resulting death of two million people (ILO, 2005). Apart from fatalities as a result of accidents at the work place, nonfatal accidents in some instances at the workplace leave victims with effects like loss of body parts, cancer, and other related musculoskeletal and reproductive disorders, skin disease, respiratory and cardiovascular diseases, mental and neurological illness (Tadesse and Admassu 2006, Punnett and Wegman 2004, Adei*et al*., 2011).Studies show that workers that work in small and medium enterprises are more likely to face/experience work-related hazard and risk. This could be attributed to inadequate or limited resources, poor technical capacity and the neglect of occupational safety and health (OSH) standards.

Regardless of the geographical location and the differences in other factors like social, physical, economic and political environment, all workers across the globe are faced with almost similar hazards at the work place. Fundamentally, these hazards can be classified into four major types: biological, physical, chemical and physiological (Rosenstock *et al*., 2006). More than half (80%) of the global workforce faced with some risk are particularly located in developing countries inexplicably share in the global burden as a result of occupational disease and injury. Whether this ill health faced by these workers is as a result of ignorance, inattention or intent there is convincing prove that work-related health conditions could be reduced considerably, often at a minimum cost (Rosenstock *et al*., 2006).

2.5 History of Lead Toxicity

As early as (AD. 23 – 79), Pliny the elder (as far back as A.D 23-79) recorded that workers who painted ships with naïve ceruse protected their face with loose bags to prevent breathing of toxic fumes from lead (ILO, 2016). In 370 B.C. Hippocrates recorded and linked a severe case of colic in a worker who dealt in metal extraction to lead exposure. Nikander in the second century B.C described pallor, colic, paralyses, and drooping limbs as some of the earliest clinical manifestations of lead poisoning. Hamilton examined white lead and used extensively records from the hospital to establish the association between exact illness and occupations, and through such investigation, it helped to identify workshops and people involved industrial process that use dangerous chemicals (Mark and James, 2010). The increase in the prevalence of occupational lead exposure during the pre-industrial era times has sufficiently been documented and it has been reported that the great Roman Empire fell due to the prevalence of lead toxicity among its citizens (Mark and James, 2010). Occupational exposure to lead became common in the later epoch of 19^{th} century and the early part of the 20^{th} century when there was a rise in industrial activities during which workers were exposed through major activities like; plumbing, painting, smelting, printing and several other related industrial activities. Franklin in 1767 prepared a list of patients who were in La Charite Hospital located in Paris with strange symptoms, which, even though those symptoms had not been recognized then, were obviously linked to lead poisoning. The entire patients on that list were in occupation that exposed them to lead (Smith, 1984 and Goldstein, 1992).

2.6 Occupational Health and Exposure to Lead in Developing Countries Although the occurrence of severe lead poisoning has been reduced in several countries, occupational exposure to lead that result in moderate and clinically symptomatic poisoning is still frequent in many developing nations. The exposure to lead among adults is usually highest in individuals who have close proximity with the metal (lead) in the production processes. There are numerous occupations that expose workers to lead which include but not limited to; panel beating, lead alloy production, battery manufacturing and recovery, paint industries, printing and ceramics, soldering, plastics and in glass production. Strict measures and regulation are put in place in most industrialized countries to limit the prevalence of occupational lead poisoning. However adverse health effect of occupational lead exposure still linger on as a problem of potentially huge dimension in developing countries (Von Schirding, 1999).

The scarcity of information on occupational lead exposure is a major issue. Lack of data on lead pollution to enhance the assessment of lead intake was expressed as a major problem hindering occupational lead exposure in Egypt (Nasralla and Ali 1985). The lack of conscious and deliberate attempt by government or lack of political

_will' and other factors like improper data management and data collection system, Lack of enforcement of health and safety policies are some of the major factors that affect the growth of occupational health and safety in low and middle-income countries (Joubert, 2002, Asuzu, 1996, Yingratanasuk *et al*., 1998). According to the ILO convention 155 1985, all member countries are expected to strengthen their environment and occupational health and safety issues through the formulation and implementation of coherent policies that is backed by and periodically review. Most developing countries have not established authorities dedicated to occupational safety and health to direct and aid the realization of the ―Action‖ at the national level as specified in the R164 occupational safety and health recommendation. Workers will be protected from occupational hazards and risks once there is the availability of occupational health services in place. High blood lead levels in adults can cause damage to the cardiovascular, central nervous system, reproductive, hematological and renal system. Damage to organ systems is as a result of occupational exposure (Roscoe *et al*., 2002). There are a lot of studies that assess the blood lead levels (BLL) in workers exposed to lead due to the nature of their occupation. The results of the study conducted among apprentices at Bursa Vocational Education Centre in Turkey indicated that the blood lead levels of apprentices were higher and that was due to occupational exposure (Pala *et al*., 2009). Findings from studies conducted in Nigeria shows a strong correlation between lead exposure and the occurrence of adverse health effects (Ayoola, 1979, Omokhodion, 1999, and Sofoluwe, 1971). Lead poisoning was reported among 40% of individuals working with lead acid battery workers in Lagos Metropolis about two decades ago (1971) (O. Osibanjo and Ajayi, 1989).

In a study to assess the blood lead levels of Automobile Technicians in two different working environments in Lagos, the results revealed a strong correlation between high blood pressure and an unusual discoloration of the mucosa of the mouth among the more organized group. The study subjects found in the organized garages had a higher prevalence of raised lead levels in the blood and a higher median blood lead level than the subjects in the roadside garages (Abdulsalam *et al*., 2015). Another study among workers of a car battery industry in Iran show a strong link between chronic occupational lead poisoning and neuropsychiatry with workers in the car battery industry occupation having blood lead concentration of 398.95 ±177.40μg/L and urine lead concentration 83.67±49.78μg/L (Kianoush *et al*.,2013). A study conducted by Kononen, 1991 in lead acid battery workers found that the greatest absolute and percentage increases above acceptable limits of blood lead levels occurred following a continuous exposure during the first three months. The blood lead levels of employees should not be allowed to be more than 30µg/dl in the first three months of employment (George, 1999). If this happens, appropriate steps should be taken, which include consideration of the placement of the worker in more suitable workstation or reassignment of the worker if the levels do not drop down to acceptable levels.

2.7 Lead in the Workplace

As a naturally occurring metal that is found in the earth's crust; lead (Pb) is dense, ductile, malleable and none-corrosive hence these properties have lead a very valuable element used in building materials, pigments to glaze ceramics, paints and protective coating, glass, gasoline additive and acid storage batteries (Florea and Busselberg, 2006). Its extensive use has resulted in a very broad environmental harm through contaminations, exposure to humans and a major public health problem in several areas in the word (WHO factsheet, 2016). During the pre-industrial revolution human exposure to environmental lead was relatively low but same cannot be said for today due to high due high increase in industrialization and mining on a large scale. The contamination of the environment with Lead (Pb) is relatively high as compared to other non-essential elements (Flegal and Smith, 1992). Varieties of human activities during the post industrialization epoch that moved swiftly throughout the environment during the mid-20^{th} century became a major cause of lead poisoning especially in children (Kersten *et al*., 2003).

According to (Clausen and Rastogi, 1977), as cited by Muhammad, most adults get exposed to lead due to the nature of their work and hence occupational exposure occur most in lead related industries such; as lead soldering in the electronic industry, painters and remodelers, battery manufacturing and recycling, automotive radiator manufacturing and repair, casting and machining lead, , metal plating operations, gun firing ranges, salvaging and recycling scrap metals, manufacturing leaded glass, autobody repair. Generally, lead exposure occurs following the direct ingestion of lead contaminated food-stuffs, water and other drinks, and from contaminated air. Hand tomouth activities may results in the direct ingestion of lead contaminated soil, dust and paints with lead pigments and this route may be vital source regarding lead intake into the human body. When pipes with lead components are used in the tap-water systems, there is the tendency of lead intake via drinking-water and this source mostly affects children. When lead levels in the air are high, exposure through lead inhalation may be significant (WHO/UNECE, 2007). Throughout a lifetime, the lead in the human body (regardless of the route of entry) is distributed between the bloodstream and bones and between blood and soft tissues. These transfers are influenced by the duration and intensity of the exposure, age and various physiological characteristics (US EPA, 2013).

A major source of lead poisoning in adults is via occupational exposure. The National Institute of Occupational Safety and Health (NIOSH), has estimated that in the United State alone, more than three (3) million workers are potentially exposed to lead in their workplace (Staudinger and Roth, 1998). Lead (Pb) is also known to account for approximately 10% (9.8%) of the world burden of burden of idiopathic intellectual disability, 4% of the world burden of ischaemic heart diseases, and 5% of the world burden of stoke (WHO, 2016). Several individuals who work as manufactures or execute repair services such battery workers, welders, radiator repairs, mechanics, and fuel dispensers perform duties that expose them to prolonged health risk as a result of the exposure to lead and majority of these people have limited or no idea about the dangers of the materials they handle. Because workers lack knowledge and the awareness on the route of exposures, many of them engage in practices at the workplace that may aggravate their exposure such poor personal hygiene, smoking, drinking while working (Gradjean , Hollnagel, Olsen, 1981 and Pala *et al*., 2009).

The chewing of _Khat‘ (*Catha adulis*) particularly in Ethiopia and among some East African countries has been found to boost lead accumulation in automotive technicians via oral ingestion. Whiles working, these technicians chew the _Khat‘ and more often they do not wash their hands each time they put the leave into their mouth. This practice makes lead entry into the digestive system easier, thereby increasing the blood lead levels (Yalemsew Adela, Argaw Ambelu and Dejene A. Tessema, 2012)

The absorption of lead into the human body is dependent on number of factors like the chemical and physical properties of the form of lead as well as the physiological characteristics of the exposed person such as; age and the person‘s nutritional status (Lead, 2001). The deposition and absorption of lead particles into the respiratory tract depends on factors like the shape and particulate size of the lead and the ventilation rate of the exposed person. Exposure to large particles of lead as a result of occupational environment may be dropped in the upper airways and then be absorbed directly through ingestion and absorption in the stomach. Minute particles tend to settle in the bronchial region of the lung, whereas particles that are smaller than one
(1) micron which is distinctive of urban air, spread to the lower respiratory tract where they get be absorbed directly enter into the bloodstream (Casarett and Doull's, 2001).

2.8 Risks Factors to Lead Exposure

Risk factors to lead exposure have been reported to intensify the absorption of lead into the human body (Were *et al*., 2008). There are numerous risk factors which may cause an upsurge in the exposure of humans to lead. These include social demographic risk factors such as age, income, education, race/ethnicity, housing vintage and poverty status among others (Industrias, 1996; Sukumar and Subramanian, 2003).The environmental risk factors includes: living close to heavy traffic road, eating contaminated foods, source of water, use of glazed ceramics, living near a lead based industry, smoking, duration of stay near an industry, influence of early childhood diseases. The occupational risk factors include; working in industries dealing with lead based products for example, paints, car batteries and radiators, drivers/conductors, petrol station attendants, traffic policemen, artisans, among other factors (Oyaro, 2000; Park and Palk, 2002; Were *et al*., 2008; Mogwasi, 2009). These may greatly contribute to elevated lead levels in the body.

2.9. Factors that Influence the Levels of Lead in Automobile Technicians

2.9.1 Exposure to Leaded Petrol

The most widely used additives in gasoline serving as anti-knocking agents are Organic lead compounds (tetraethyl and tetra methyl lead) (UNEP, 1999). The largest source of lead poisoning has been attributed to leaded petrol globally. Consequently, the recommendation that came out of the World summit on Sustainable Development in Johannesburg in 2002 was to with immediate actions phase out all leaded petrol in all parts of the world (UN, 2002). The use of organic lead compounds as additives in fuel is still a practice in developing countries. In Nigeria, the lead content of local automobile fuel is very high. There have been studies that suggest that emissions from automobiles are a major source of lead in the country. Some traces of lead are also present in diesel oil, lubricating oil and kerosene. In addition to occupational exposures, automobile technicians are also exposed to lead in their general environment. Lead poisoning of high doses arises from environmental exposures through varied sources but most importantly due to high gasoline lead (Kakulu, 2003). Lead poisoning of high doses, therefore, arises from occupational and environmental sources probably due to this high gasoline lead. Thus the lead absorbed due to occupational exposure is superimposed on lead absorbed via other sources (Sayo Fakayode and Olu-Owolabi, 2003).

2.9.2 Operating Hours

Exposure to lead is directly proportional to the number of operating hours hence, the longer the working hours in a day the greater the exposure to lead (Abdulsalam *et al.*, 2015). The working days of automobile technicians due to the nature of their work could be said to be on seven days a week. Depending on the clients demands, most automobile technicians that reside near their workshops are said to work for 24 hours a day. Majority of the respondents (85.4%) among battery chargers in Lagos in a study revealed most workers were in their workshop from Monday to Saturday (Alayande, 2000). The average working days in a week in the study was reported as 4-6 days.In a study on automobile technicians in Lagos, it was reported that work started at the various workshops from 8 am till 7 pm. The study concluded that 98% of workers resumed from 8 am till 6pm (10 hrs) and that only 2% reported work hours less than 8 hrs (Aiyenigba, 2005).

2.9.3 Duration of Exposure

The dangers associated with lead have been established to increase with the duration of exposure. A research conducted in Enugu revealed that the usual period of exposure for battery workers will not be 40 hours a week but 7 days a week of 24 hours each day. It was also reported in Benin that workers that had been in the trade of battery charging for a period of 1 to 4 years have high BLL (Okojie, 1989 and Asogwa, 1979). Though the linear correlation between the levels of lead in the blood and duration of exposure was poor in a recent study on automobile technician in

Lagos, it was reported that a large proportion (37%) of the workers had worked as _masters‘ for more than10 years on the job. This varied from the study in South West of Nigeria where majority of technicians (53-60%) had between 5-10 years' work experience on the job though apprentices were excluded from study (Jinadu, 1982).

2.9.4 Sucking of Fuel

There are reported cases among mechanics of lead poisoning and death resulting from direct ingestion and inhalation of gasoline resulting from manual sucking of fuel from tanks of vehicles which they repair. The use of petrol to wash hands among automobile technicians has been reported to be more than the use of soap and water. Sucking of petrol and washing of hands with fuel results in the absorption of lead through mucosa, and this, with inorganic lead from exhaust fumes may result with an increased BLL as has been reported for automobile mechanic (Grobler *et al.*, 1985).

2.9.5 Diet and Eating Habits

Fapohunda and Rutenberg, 1999 reported that most males in Kenya are the head and bread winners of their family. Furthermore, they work in areas that expose them to heavy metal pollution such as lead and because of their busy schedule they are unable to eat foods which may help their bodies to have the required levels of essential elements (Fapohunda and Rutenberg, 1999; Oakes and Slotterback, 2005). These males are found many times taking very poor diets for example tea, mandazi, roasted maize and other fast foods mostly prepared in roadside kiosks which further increases their risk of Pb ingestion. These poor diets often lead to deficiency of important essential elements in the bodies of males. Several researchers have reported that deficiency of essential minerals such as Zn, Ca and Fe exacerbates the absorption of lead (Wilhem and Hafner, 1993; Satarug *et al*., 2000; Nowak and Chmielnicka, 2000; Imran *et al*., 2003). Further, it has been reported that nutritional factors for example irregular patterns of feeding, high intake of fat, marginal calcium ingestion and Fe deficiency have also been linked with susceptibility to Pb toxicity (Mahaffe, 1995). Lead is nephrotoxic and interferes with vitamin D metabolism (Vahter *et al*., 2002) which further affects the body's uptake of calcium from the food. It is important to note also that the human males are not exempted from diseases and ailments that are brought about by essential trace element deficiencies, it is therefore imperative that human males are advised accordingly on proper eating habits. This will have a long term effect on reducing the effects of lead pollution besides reducing its absorption in the body.

Fasting and foods that have low levels of calcium iron and vitamin D have been shown facilitate lead absorption. 20-70% of ingested lead is absorbed (Lead, 2001). Gastrointestinal tract absorption of lead in young children is 42%-48% versus 8%10% in adults (George, 1999).When lead gets into the body, it is basically distributed among these three compartment; blood, soft tissues such as the kidney, liver, spleen and in mineralizing tissues such as the bone and teeth (Karri *et al*., 2008, Casarett and Doull's, 2001). About 95% of the lead burden or absorbed in adults is deposited in the bone and teeth. Since lead is a cumulative toxicant, it makes the process of clearance much slower which could be attributed to the re-release of lead from bone. Adults become more susceptible to toxicity due to certain risk factors; these include deficiencies in calcium and iron, old age, disease of organs targeted by lead (for example the brain, the kidneys), and possibly genetic susceptibility (Kosnett *et al*., 2007).

Contaminated hands of automobile technicians has become of the important source of occupational lead poisoning particularly where there is habitual act of feeding with bare hands and fingers that is closely linked with poor hygiene. It is also known that various automobile technicians consume their meals in the workshop (Far *et al,* 1993).

Automobile technicians who ate with unclean hands at least once a week had elevated BLL which might as a result of their higher exposure and eating with bare hands. The habit of chewing of lead containing connective wires among workers can also cause exposure. The likelihood of ingestion of lead through the habit of feeding with barehands immediately after work in developing countries had been reported in previous studies (Okojie, 1989 and Asogwa, 1979). In a study conducted in Lagos, nearly 95% of the respondents in the study eat with their bare hands. It was also revealed that the metals were available for incidental ingestion were from the handling of food or non-food items and hand-to-mouth contact(Alayande, 2000).

2.9.6 Smoking

The degree of uptakeof lead from the respiratory tract is boosted by smoking habit (Karita *et al.,* 2005). Smoking in workshops where materials containing lead are used make workers prone to lead through frequent contact of lead-contaminated hands with their mouth (Tozun, Unsal, and Sirmagul, 2009). Thus, lead in the smoke isingested through the digestive route. Moreover, the lead in the smoke of a cigarette is taken by respiration. Smoking, which causes lead intake by one of those routes, is a risk factor for lead poisoning (NIOSH, 1978).Lead has multiplying effects on smokers. Smoking potentiates the negative effects of workplace exposure to lead. Smoking and workplace exposure to various chemicals are matters of clinical as well as public health significance. The frequency of smoking on duty was found to be very low in a study on battery chargers in Lagos as it was reported that 8.7% of respondents smoke while on duty (NIOSH,1978, Rose *et al.*,1987 and Alayande, 2000).

2.9.7 Utilization of Personal Protective Equipment

Automobile mechanics rarely use personal protective equipment with most of them only sticking to an overall protective gear (Oluwagbemi, 1991). The use of PPEs is very low among workers and that has always been a problem (Omokhodion, 1999). There might be a vivid and discomforting hazard but the personal protective equipment is sometimes considered as less _tolerable‘ than the hazards (Fatusi and Erhabor, 1996). The level of education and complaints of discomfort has been linked with the use of personal protective equipment (Onajole *et al.,* 2004). In a study on automobile technicians in Lagos regarding the use of personal protective equipment, several reasons such as cost (82%), belief that it is not necessary and the perception that it is uncomfortable were given by respondents for not possessing any personal protective equipment (Aiyenigba, 2005).

2.9.8 Awareness of Hazard of Lead Exposure

Awareness of lead as a hazard in the workplace could determine exposure and hence its level in the human body. In a study conducted in Benin, the awareness of lead as a hazard was poor (35%) among workers (Okojie, 1989). Another study by Abdulsalam *et al.,* in Lagos among organized and roadside garages observed high awareness of lead hazard with (92%) and (92.8%) level of awareness respectively in both organized and road side technicians. Another study in Ilorin revealed increasing knowledge of hazards with increasing in age, educational level and lenght of years on the job. However, the association showed no statistical significance(Awoyemi, 2002). A related study in Lagos among automobile technicians conducted in 2005 reported high knowledge (93.6%) of all hazards (Aiyenigba, 2005). In another study on battery chargers in Lagos, 96.7% of those surveyed were aware of the hazardous nature of their profession (Alayande, 2000).

2.9.9 Effects of lead on Humans

Regardless of how toxic a substance is, it can only cause toxicity in a child, adult or both only when there is an exposure. Following a adequate level of exposure to the substance, several other processes begin which include; biological uptake, target organ contact, and manifestation of biological change of which contribute disease causation and other health effects (ATSDR, 2012 and ATSDR, 2013).

Over the past two and half decade, there has been growing concern regarding the exposure of lead at low-levels and its adverse effects on the human health and the ‗normal' body burden of lead. In an occupational context, the ‗no effect level' (NOEL) of lead exposure is being observed as increasingly sensitive measures of the physiological effects of lead are developed (Lewis R, 1997). In adults, increased blood lead levels have the tendency of damaging the cardiovascular, reproductive, haematological, central nervous and renal systems. The majority of cases are occupationally related (Roscoe *et al*., 2002). Most industrial populations including automobile technicians are at risk of occupational exposure to lead (Abdulsalam *et al.*, 2015). In an estimation made by the National Institute of Occupational Safety and Health, in the United State alone more than three (3) million workers are potentially exposed to lead in the work place(Staudinger and Roth, 1998).

Occupational exposure to lead occurs mainly through lead dust and fumes as well as direct ingestion of lead (Abdulsalam *et al.*, 2015).The most sensitive organ in the human body to lead exposure is the brain (Cleveland *et al*., 2008). Various types of brain damage has been linked with lead exposure and some of which are; aggression, problem with thinking (cognition), poor coordination of fine movements (fine motor control) as well as difficulties in organizing actions, decisions and behavior (Cecil *et al*., 2008). There have been reports on lead encephalopathy (a progressive degeneration of certain parts of the brain) occurring in adults at extremely high lead exposure levels of about 460μg/dl with more severe symptoms like include delirium, lack of coordination, convulsions, paralysis, coma and death (Lead, 2001 and ATSDR, 2010). Higher levels of lead in the blood is correlated with a lower cognitive performance and other related psychiatric conditions like depression and anxiety (Jacobs *et al*., 2002). There are records on the mild neurological and behavioral effects following lead exposure among occupationally exposed individual with lead levels between the range 40µg/dl – 120µg/dl (ATSDR, 2010). Some of these effects manifest as; reduced sexual desire, mood-swing/ depression, dizziness, headache, fatigue, impaired concentration, irritability, impotence, forgetfulness and lethargy. Lead being nephrotoxic inhibits the metabolism of vitamin D, and hence, further inhibits the body‘s ability to absorb calcium from food (Vahter *et al*., 2002). It must be noted that diseases that occur as a result of essential element deficiency affects all individuals with compromised health status, it is therefore imperative that automobile technicians are advised on proper eating habits.

There is currently little documentation on the lowest level at which lead can adversely affect the kidney. However, there are several studies that show a strong correlation between lead exposure and renal effects (reduction in renal function) (ATSDR, 2010 and NTP, 2012). Han *et al.,* also reported the impairment in renal function as well as kidney disease at high exposure levels. Even at low (< 5µg/dl) there is an adverse effects on kidney function by lead. Thus higher chances of chronic kidney disease and a reduction in the estimated glomerular filtration rate as well as creatinine clearance (NTP, 2012). At (<10µg/dl) blood pressure is increased resulting in an increased risk of hypertension in adults, however continuous exposure can expose the kidney to toxic stress and if unrelieved, may bring about chronic and usually permanent lead nephropathy (NTP, 2012). Chronic lead nephropathy is as a result of many years of lead exposure which is also shown in kidney biopsy by moderate focal atrophy, loss of proximal tubules and interstitial fibrosis (Benjelloun *et al*., 2007).

The effect of lead after exposure can result in two types of anaemia, usually Hemolytic anaemia which has been associated with acute high-levels lead exposure and Frank anaemia which manifests only when there is a significant elevated level of lead for a long period (ATSDR, 2010). Lead induces anaemia by hindering with heme biosynthesis and by fading red blood cell survival, also the anaemia as a result of lead exposure is hypochromic and normo - or microcytic which is linked to reticulocytosis (ATSDR, 2010).

There are little population studies that report a possible association between cardiovascular disorders like; ischemic coronary heart disease, cerebrovascular accident and peripheral vascular disease and lead exposure (vaziri and Gonick, 2008). Nevertheless, several epidemiological and clinical studies have reported on association between chronic lead exposure and increased blood pressure (vaziri and Gonick, 2008). The exposure to lead has been found to be one of the factors that may contribute to the onset and development of hypertension (ATSDR, 2010). Despite the weak link between hypertension and lead exposure at low-to-moderate levels, higher exposures (basically seen in working environment elevates the risk of hypertension and other heart and cerebrovascular diseases as hidden effects (ATSDR, 2010). In a study by Wedeen *et al.*, to know the effects of occupational lead exposure, they observed tubular dysfunctions in patients who experienced biopsy. The revelation from such studies predicts that lead nephropathy may be a vital occupational hazard. Continued lead exposure is associated with increased blood pressure and there are other studies that show the correlation between lead exposure and heart rate variability, coronary heart disease, death from stroke, but there is limited evidence on this (Lin & Huang, 1994).

The toxicity of lead in male reproductive system is shown in the deposition of the metal (Lead) in the testes, epididymis, vas deference, seminal vesicles, and seminal ejaculation (Roy *et al.*, 1986). There are several studies that implicate lead as causative factor to reproductive and developmental effects. These effects at low exposure levels have not been well established, but current studies on reproductive functions in human suggests that occupational exposures has the tendency to contribute to a reduction in the total sperm count and the frequency of sperm abnormalities (NTP, 2012). Others studies also report the association between lead levels at <15µg/dl and adverse health effect on sperm and semen. However, the duration of these effects is unclear in human after the exposure ceases (NTP, 2012). Lead can adversely affect the total sperm count, retard the activities of a live sperm, sperm morphology as well as biochemical disruption of enzymes and hormones (Roy *et al*., 1986). Lead exposure affects the reproductive system of both males and females. When the blood lead levels exceed 40µg/dl it can result in low sperm count and other changes in the volume of sperm in male‘s sperm motility and the general morphology are also affected at this level (Navas-Acien *et al*., 2007).

Another vital argument to note is that, although there is no known physiological role for lead in the human body (Wolf *et al*., 2007; Rubin & Strayer, 2008); its damaging effects are manifold. At the cellular level, the harmful effects of lead have been well studied and documented. Other heavy metals, with lead inclusive, generate reactive radicals responsible for the damage of the cell structures, including DNA and cell membrane (Kosnett, 2006). Lead is also known to hinder the activities of the enzyme that aid the synthesis of Vitamin D also with enzymes responsible for the maintenance of integrity of the cell membrane. Elevated levels of lead in the blood from 50 100µg/dl in adults is known to be linked to relatively severe conditions such as permanent impairment of central nervous system function (Bellings *et al*., 2004).

There is an association between the development and health of bones and at high levels, lead can cause growth retardation in children (ATSDR, 2017). An in vitro studies have found an association between lead exposure and decreased bone mineral density (BMD) such that animals that were exposed to lead had a reduction in bone mass and made them more susceptible to fracture, conversely there are limited human studies on this fact (Beier *et al*., 2013).

2.9.10 Management of Lead Poisoning

It has become totally essential to prevent more exposure to lead following individual's initial exposure (Hunter, 1978). The early detection of cases will aid in preventing from further exposure. The fundamental and most important step in the treatment of people with high BLL is the removal of such individual from all known sources of hazardous lead exposure, whether occupational or non-occupational (Kosnett, 2007).

In managing lead toxicity, the main objectives in the management process are the prevention of further exposure to lead, absorption, removal of lead found in soft tissues and the prevention of a relapse (Park K. 2007). In individuals with evident lead intoxication, the medical treatment process involves; removal from source, decontamination, general supportive care, symptomatic treatment, cautious use of chelating agents and assisted elimination of the toxin (Pb) (Okaro, 2007). The removal of unabsorbed lead from the gut will be done using a saline purge (Park, 2007). The treatment for lead toxicity requires the use of chelating agents, predominantly edetate calcium disodium (CaEDTA), dimercaprol, penicillamine, and succimer. The administrations of these are done orally with relatively few side effects. Chelation is recommended for adults with BLL exceeding 80µg/dl or if these levels exceed 60µg/dl with symptoms haven developed (Braunwald *et al.*, 2001) If the only symptom shown by an individual following exposure to lead is anaemia, the following should be done; removal from exposures, high milk consumption (about two pints per day) or calcium lactate (10mg) daily by mouth. In severe cases of anaemia, large quantities of milk and milk products should be taken together with calcium lactate (5g) three times daily and administration of haematinics (Asogwa, 2000).

2.9.11 The use of Biomarkers to Detect and Quantify Lead exposure

Lead has been a major center of attention when it comes to environmental health research for many years. The breakthrough of studies in humans was hugely assisted by the methods such as the graphite furnace atomic absorption spectroscopy for the exact and reliable measurement of lead found in the human blood (measured in units of micrograms per deciliter [µg/dL), a method that is now generally available and used or the surveillance and monitoring, as well as for research. The generic term biological marker (biomarker) is the term that is used for a system that mainly measures the interaction existing between a biological system and a physical, chemical or a biological agent. Determining the recent and or past exposure of lead burden in human is reflected via bio-monitoring. Hence, the right selection and measuring of lead using a biomarker is of critical significance for proper health care management, public health decision making and suitable preventive activities at the primary level (Fernando *et al*., 2005 and Berlin *et a.*, 1980). A fraction of lead after absorption in the body is accumulated and deposited in the various tissues and organs. The rest of the toxin is excreted unchanged or as polar metabolites. Following exposure to toxins from the environment or through diet, the human body has an incredible way of eliminating various variety of chemical absorbed. Many toxins particularly polar substances, exit the human body via exhaled air and urine. A very minute fraction of the chemical is also removed through the saliva, bile, sweat, milk and faeces (Kozłowska, 2003).

Most biomarkers used include human tissues such as teeth, finger nails and toe nails, hair, blood and other body fluids. Exposure of an organism to metals is monitored via measuring their concentrations in urine, blood, nails and hair (Naginiene *et al*., 2002; Samatha *et al*., 2004; Mehra and Juneja, 2005; Nowak and Chmielnicka, 2000). The actual nature of lead exposure is mainly dependent on the complex nature of toxicokinetics of lead that occurs within the human body compartments thus, blood and soft tissues and cycling of lead between bones. The blood lead levels, mainly red blood cells lead represents the soft tissue lead and the basic biomarker for the assessment of the exposure to lead. It is also used for both screening and diagnosis purposes in monitoring the biological burden of body lead absorbed. In adults, (50%) of inhaled lead is transported to the bloodstream and 10% of lead absorbed through diet, nearly all (98%) is found in the blood cells (Desilva, 1996).

The blood and soft tissues ensures the fast absorption of lead which is slowly released into the bones. Lead that is accumulated in the bone may serve as an endogenous source, which is later released slowly back into the bloodstream in after exposure has stopped. Lead is also transferred to the unborn baby during gestation (IPCS, 1995). In recent times, the mainly used biological fluid for the assessment of lead exposure is the blood. Whole blood is also used for screening and diagnosis purposes and for biomonitoring purposes in the long term. Blood lead measurement reflects the recent and past exposures, the latter as a result of mobilization of accumulated lead from bones back into the blood even in individuals with little exposure to lead. The mobilization of lead back from the bone into the blood contributes about 45% to 75% of lead found in the blood (Smith *et al*., 2002; Gulson *et al*., 1996; Barbosa *et al.*, 2005).

In a study to assess the environmental, dietary, demographic and activity variables linked with biomarkers of lead exposure, it was revealed that blood lead levels was found to correlate with;

a. House dust concentrations of lead
b. The duration of time spent working in a closed workshop and
c. The year in which the subject moved into the residence (Roy *et al*., 2003).

The long term bio-monitoring of lead for occupationally exposed individuals is done using urine. At the glomerular level, filtered Pb give rises to urine Pb which later excreted via the kidneys. According some authors, the levels of lead in the urine adjusted for glomerular filtration rate can serve as a substitute for plasma Pb. The correlation between U-Pb with BPb among occupationally exposed individuals was sufficiently close to predicts that U-Pb can be an ideal alternative to BPb on a group basis, but not close enough to allow U-Pb to predict BPb on an individual basis (Barbosa *et al.*, 2005;Tsaih *et al.*, 1999).

Research has found that the correlation between the concentration of plasma-Pb and urine-Pb was better than between BPb and U-Pb for occupationally exposed workers with low levels of lead exposure. The use of high-precision Pb isotope ratio measurements found that U-Pb concentration represented about 10% of that in whole blood. Nonetheless, the correlations were not particularly robust. In contrast, correlations with isotopic ratios were excellent (Hirata *et al*. (1995).

The cortical bone gives a mean of 0.43 µg Pb each day that is excreted in the urine, while trabecular bone contributes as much as 1.6 µg daily (Tsaih *et al*. 1999). The difference between Pb kinetics of exposed and non-exposed subjects after the administration of CaNa2EDTA was observed (Cavalleri *et al*. 1983). After 5 hours following the administration of CaNa2EDTA, the levels of lead in the blood was the same for unexposed subjects. Nonetheless, plasma-Pb levels found in the unexposed subjects reduced by as much as one half while the urine-Pb reduced by a factor of 10. Study subjects in the Pb-exposed group with the same amount of chelation therapy cause an increase in the plasma-Pb levels by a factor of 2, while BPb levels decreased by a factor of 2, with a higher urine-Pb excretion. Consequently, it has become evident that in non-exposed subjects, Pb fraction in soft tissues which is in equilibrium with that in plasma compartment is a major contribution for urine-Pb. The amount of erythrocyte-bound Pb is directly proportional to the binding forces, and that represents a major fraction of Pb that is released from the membranes of the red blood cells into the plasma and later filtered by the kidney. Due to the high volume of excreted Pb, the kidneys are unable to rapidly remove it from the blood stream hence accounting for the temporal elevation of plasma-Pb levels. The accurate and proper analytical results for urine-Pb is greatly dependent on the availability of reliable urine quality-control materials and reference materials certified for Pb content and participation in external quality assessment schemes. However, there is the tendency for urate salt to move quickly out of the urine during transit and storage can also be a complicating factor during analysis. Furthermore, because few works have studied the link between urine-Pb and other biomarkers, the use of urine-Pb measurements is essentially limited to long-term occupational monitoring program, monitoring patients during chelation-therapy, and, until very recently, to clinical evaluation of potential individuals for chelation therapy (Fernando Barbosa *et al.*, 2005).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Design

A cross-sectional study was conducted from May to December 2017 among male adults between the age of 18 and 60 years old working in the Sunyani Municipal Magazine of the Brong Ahafo Region of Ghana.

3.2 Study Area

Sunyani Municipal is one of the twenty-two administrative districts in the BrongAhafo Region of Ghana. It lies between latitudes 7˚ 20‘N and 7˚ 05‘N and Longitude 2˚ 30‘W and 2˚ 10‘Wand shares boundaries with Sunyani West District to the North, Dormaa District to the West, Asutifi District to the South and Tano North District to the East. There are effective economic and social interactions with the neighboring districts which promote resource flow among these districts.

Being the capital of the region, the area covers a land area of 829.3 Square Kilometers (320.1 square miles). Of this entire land scape about one third is not cultivated or inhabited which gives an avenue for further development. According to the recent Population and Housing Census, the total population of the area stood at 123, 224 which represents 5.3 % of the region‘s population. The gender breakdown of the population was given as; 49.9% for males and 50.1% for females. The total age dependency ratio for the municipality is 54.0, the age ratio for males is higher (54.4) than that of females (53.62).

The municipal has a large mechanic community which covers an area of about approximately 10,115 $m^2$with large number of automobile technicians of different trades who offer the needed services to individuals living in and around the municipality with a relatively high number of vehicles. The automobile technicians have an organized association. The association, known as the Garages Association of Sunyani serves as a unit comprising of all the 10 zones located at different areas within the mechanic community. Each zone consists of a number of workshops where these technicians execute their job. The workshop canteen and the office of the garages association are located at the center of magazine.

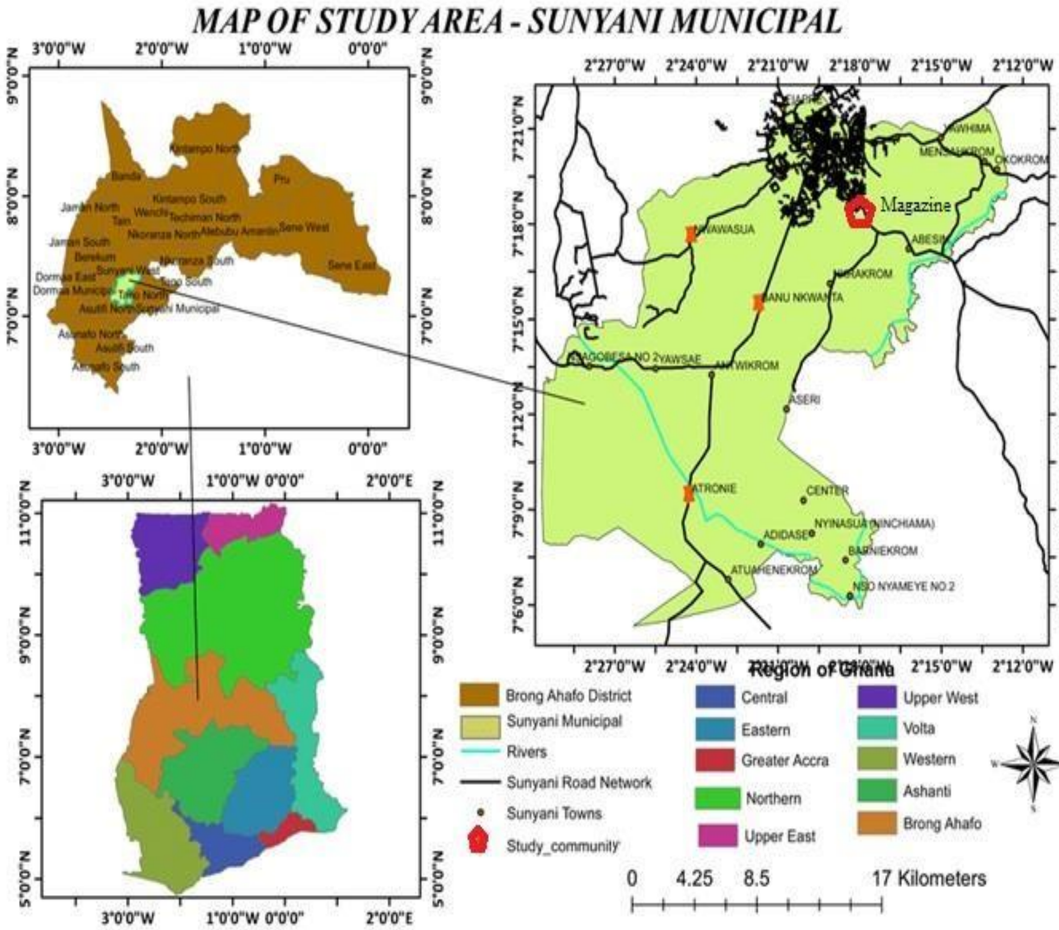


Figure 3.1: Map of Sunyani Municipal

3.3 Source/Study Population

The source population for the study consist of automobile technicians who work in the Sunyani Municipal magazine, while the study population involved two hundred (200) respondents between the ages of 18 to 60 years (see section 3.5.1 and 3.5.2for sample size calculation and sampling procedure respectfully) who are involved in the following job specialty; spray painting, Battery charging/repair, radiator repair, auto electrician and mechanics.

3.3.1 Inclusion criteria

1. The study subject should be a member of the garages association in the Sunyani Magazine and fall within the age range of 18 to 60.
2. The technicians should have worked continuously for a minimum of six months in his unit or field of specialty.
3. The technicians should be willing to follow the study protocol and complete the study.

3.3.2 Exclusion criteria

1. Automobile technicians who are less than eighteen years (18) and have not worked for more than six months continuously on the job were excluded from the study.
2. Automobile technicians who do not execute their activities within the confines of the magazine were not included in the study.
3. Any automobile technicians who had participated in a similar study in the last three (3) months to the commencement of the study were excluded.

3.4 Study Variables

3.4.1 Main Determinants

The main determinants of interest include; (i) Awareness on Pb hazards, (ii) Occupational related factors (iii) Practice of personal hygiene and (iv) lifestyle factors.

3.4.2 Outcomes of Interest

The main outcomes of interest in this study include self-reported health symptoms and the exposure levels of lead (Pb) among automobile technicians via urine analysis and also know the factors that put them at risk.

3.4.3 Confounding Variables

The following variables were considered as potential confounders; age, sex, diet, genetics and cigarette smoking (ATSDR, 2017).

3.5 Sample size calculation and sampling procedure

3.5.1 Sampling Size Calculation

The sample size was determined using the Yamane (1967) formula for calculating population sample size.

$n = \frac{N}{1+Ne^2}$ ……………………………………………………………………….Eq. 1

Where; n = sample size to be calculated N = actual population size e = standard error which depends on the required confidence level set by the researcher.

In this case, the confidence level was 95 percent. The value of ―e‖ therefore was 0.05.

$n = \frac{1076}{1+1076(0.05)^2}$ ……………………………………………………………..Eq. 2

$$n = \frac{1076}{1 + 1076(0.0025)} \quad n = \frac{1076}{1 + 2.69}$$

$$n = \frac{1076}{3.69}$$

$$n = 291$$

The sample size was determined using the Yamane (1967) formula for calculating population sample size. From the said (Yamane) formula a sample size of 291 should have been used considering the population marked for the study but due to 5 five selected job specialties and lack of fund for lab analysis, 200 out of the 291 samples obtained was used instead. In all, total sample sizes of 200 respondents were considered for the study.

3.5.2 Sampling Procedure

The municipal magazine has 10 zones where these technicians execute their job with a total population of 1076. These zones of the magazine were the clusters/area within which samples were collected. Therefore, from equation two (2) in section 3.5.1 a total of 200 respondents were sampled for the study among 5 job specialties. Purposive sampling was used to select respondents under each job specialty in each of the 10 zone based on the number of members in the garages association register.

3.6 Data Collection Procedure

The execution of the field work for questionnaire data collection was done in three (3) phases;

Phase 1: Stakeholder meetings

Phase 2: Selection and enrolment of study participants

Phase 3: Data collection

3.6.1 Stakeholders Meetings

There were a number of meetings with stakeholders in the municipality to make known the aims of the study to them as well as to seek their permission and views on the exposure of automobile technicians to lead (Pb). The stakeholders involved were;

(a) the chairman and members of the Garages association of the Sunyani Municipality, (b) the municipal assembly, and (c) the assembly man of the area.

3.6.2 Selection and Enrolment of Study Participants

The study consisted of 200 automobile technicians selected from 10 zones within the magazine who were asked to freely express their interest to participate in the study. Participants were selected based on sampling procedure and also on an inclusion and exclusion criteria (see 3.5.2, 3.3.1 and 3.3.2)

3.6.3 Data Collection

The data collection tools for the study include a well-structured questionnaire and a 20ml plastic container for urine sampling.

3.6.3.1 Questionnaire

A well-structured questionnaire containing both open and close-ended questions was used to solicit information from respondents. The questionnaire was completed by the technicians or with the help of the researcher. An average time of 10 minutes was required to complete a questionnaire. The questionnaire consisted of 3 parts; Part A the socio-demographic characteristics of respondents, Part B occupational related risk factors, Part C personal Hygiene Practices, and Part D the self-reported health symptoms.

3.6.3.2 Urine sample Collection

Urine samples were collected between the hours of 8:00 and 10:00am from study subjects in the magazine using acid-washed, decontaminated 20ml polyethylene containers. All subjects were notified to void out the first portion of the urine stream before collecting the urine into the 20ml polyethylene containers containing 2g of bartiburic acid as preservative. Urine samples were then frozen at 20 ^{o}C till further treatment and biological sample analysis for the determination of the lead (Pb) levels at the Ghana standard Authority.

3.7 Quality Control

1. The questionnaire was pre-tested and standardized before data collection began.
2. Instruments were calibrated and test kits were quality controlled prior to analysis.
3. Standard Operating Procedures (SOPs) were developed and meticulously followed in all analytical steps. The urine analysis for Pb was conducted twice on each sample at the Ghana standard Authority and the average value was recorded accordingly.

3.7.1 Urine Sample Analysis for Pb

The concentration of Lead (Pb) in the urine samples was determined using Varian AA240FS Fast Sequential Atomic Absorption Spectrometer. Urine samples were digested using conventional wet acid digestion as reported by Memon *et al* (2007); 0.5 ml of and urine was directly taken into a Pyrex flask, 3 ml of freshly prepared mixture of concentrated HNO_3- H_2O_2 (2:1, v/v) was added and allowed to stand for 10 minutes. The flask was digested at 60-70 ^oC for an hour after which the digest was treated with 2ml of nitric acid and few drops of H_2O_2,until a clear digested solution was obtained.

Plate 1: Sample Collection Point showing a Spray Painter applying Filler

Plate 2: Sample Collection point showing a mechanic at work

Plate 3: Sample Collection point showing a welder at work

3.8 Data Analysis

The questionnaire were cross checked and coded well to help check validity prior to analysis. Data obtained from the field was subjected to statistical analysis using computer software the Statistical Package for Social Sciences (SPSS) version 20.1.

The software was mainly used to provide descriptive statistics of the various variables studied. Descriptive statistics as well as tests for associations using bivariate and multiple linear regression analysis were used to compare the relationship between between the outcome and independent variables. The correlation between lead (Pb) levels and self-reported symptoms were also determined.

3.9 Protection of Privacy

Study participants were at liberty to answer or not to answer any survey questions that they felt compromised their privacy. Also, all data captured were not subject's identifiable and participants were assured of the security of their privacy.

3.9.1 Informed Consent

Informed consent was sought and obtained from all study participants. An oral script introducing the study was issued to the study participants and also read out to those who could not read and write by a translator. A written consent for the study was issued to interested participants and or read out to participants by a translator. Once all raised questions were addressed by the researcher, an interview was conducted to those that agreed.

3.9.2 Provision to Prematurely end Study Subject's Participation in the Study Any study participant that opted to be interviewed in a location of their choice to increase privacy was accorded that right. In any instance of an adverse event or situation of distress, a subject‘s participation in the study came to an end. There were no such instance and hence all study participants successfully ended the study.

3.9.3 Record Storage and Protection

All research related records, data, and urine specimen were protected against inapt use or disclosure, or malicious or accidental loss or destruction in order to ensure and facilitate the confidentiality of all subject data. All data and any other study-related material was under restricted assess on a laptop. Routine electronic back up and encryption of digital data was also done together with the provision of updated antivirus software to ensure the security of the data stored on the laptop.

3.9.4 Data Status at the End of the Study

All urine samples were destroyed together with the containers identifiable stickers after laboratory analysis. The responses solicited from the subjects were also deleted from their storage device (digital format) after 4 years retention. The study survey forms were destroyed at the end of the study. It is anticipated that retention period may change, although urine samples was retained until the completion of the study. It is also necessary to collect and maintain data linked to subjects‘ identities in anticipation of the need to be able to return the Pb analysis results to those who desire it, and also advice those with levels above the recommend limit to abstain from the work while seeking medical attention for a while for the sake of their health.

3.9.5 Retention of data and/or specimen details

Retention of data by the investigator was done for future research and/or the creation of repository. In the situation where it becomes necessary for future research in the same study area, a longitudinal study can be done to show how conditions have changed over the period.

3.9.6 Ethical Considerations

Permission was sought from all study participants and the entire study subject‘s voluntarily took part in the study. Ethical clearance was sought from the Kwame Nkrumah University of Science and Technology Committee of Human Research and Publication Ethics. Permission was also sought from the opinion leaders and relevant stakeholders in the study area. Both oral and written consent was sought from each study subject and before participants gave their consents, the participant information leaflet and consent form which contains the benefits, risks, and procedures for the research was read out and explained to each participant before they signed or thumb printed. Confidentiality of data that was collected and subsequent findings was assured by using only numbers for each participant. Participants were at liberty to terminate participation at their convenience. Any subject who demanded to know their levels of Pb in the urine sample was given that opportunity. Assurance was also given to subjects that the urine samples collected were only used for research purposes and all samples after analysis were retained to be destroyed later.

CHAPTER FOUR

RESULTS

4.1 Demographic Characteristics of Study Participants

A total of 200 respondents were interviewed in the study. A majority (55.0%) of them were in the age range 31 – 45. A majority (74.0%) of them were also single. Three out of every ten of them had Primary education (30.0%), JHS (29.5%) or SHS (29.0%) level of formal education. 22.0% of them were currently smoking and 12.5% of them takes alcohol. Table 1.

Table 4.1: Demographic Characteristics of Respondents.

Variables	Frequency (N=200)	Percentage
Age group 18 – 30	18	9.0
31 – 45	110	55.0
46 – 60	72	36.0
Marital status		
Married	52	26.0
Single	148	74.0
Religion Christians	125	62.5
Muslims	75	37.5
Education None	23	11.5
Primary	60	30.0
JHS	59	29.5
SHS	58	29.0
Currently smoking		
Yes	44	22.0
No	156	78.0
Takes alcohol		
Yes	25	12.5
No	175	87.5

4.2 Urine Level among Different Job Specialty

Table 4.2 shows that the mean urine lead level was significantly different among the various job specialties of the respondents. Radiator repairers (5.28µg/L) recorded the highest urine lead level, followed by Battery charging specialist (4.96µg/L), Spray painters (4.44µg/L) and then Mechanics (3.53µg/L). Auto-electricians recorded the least mean urine lead level of 1.94µg/L.

Table 4.2 Mean Pb-levels Among Different Job Specialties

Job Specialty	Frequency (n)	Percentage (%)	Mean ± SD
Mechanic	44	22	3.53 ± 2.95
Spray painter	30	15	4.44 ± 3.09
Battery charger	32	16	4.96 ± 3.37
Auto electrician	56	28	1.94 ± 2.45
Radiator repairer	38	19	5.28 ± 2.68

4.3 Job Specialty of Respondents

Fig. 4.1 shows the distribution of job specialty among the respondents. 22.0% (n=44) of the study participants were Mechanics, 15% (n=30) were spray painters and 16.0% (n=32) were Battery Chargers. 28.0% of them were Auto electricians and 19.0% (n=38) were Radiator Repairer.

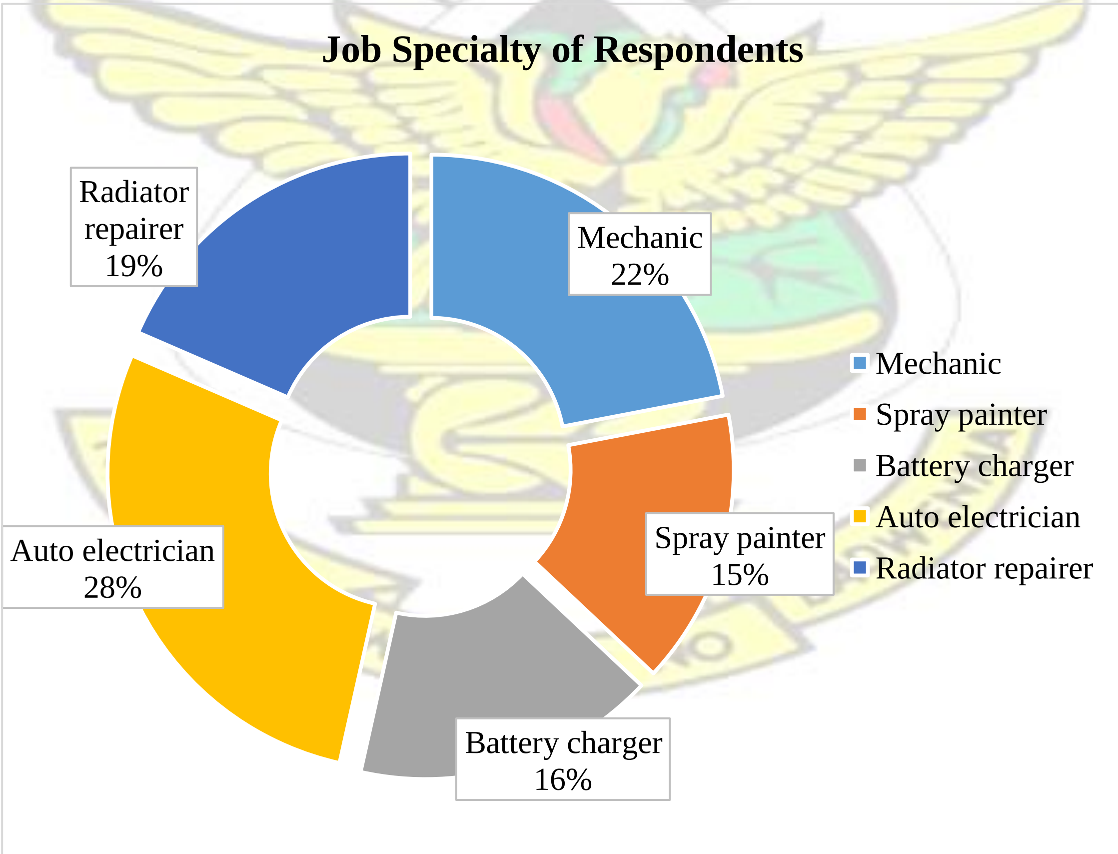


Figure 4.1: Percentage Distribution of Job Specialty among Respondents

4.4 Prevalence of Self-reported Health Symptoms among Respondents

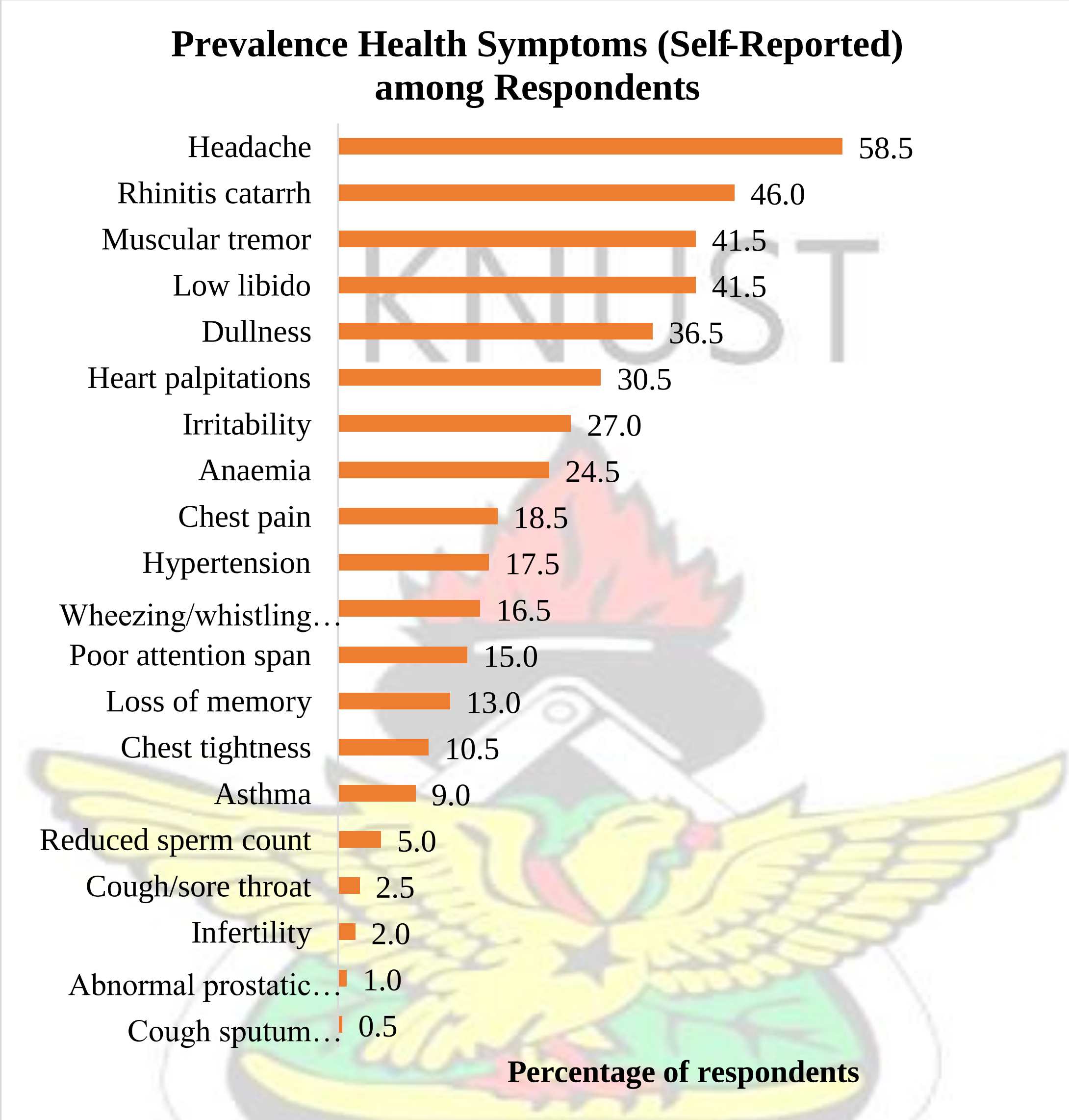


Figure 4.2: Prevalence of Self-Reported Symptoms of Respondents

4.5 Association between Urine lead level and Job Specialty

Table 4.3 shows the association between urine lead level and job specialty. The Oneway ANOVA test shows that the mean urine lead level was significantly different between the various job specialties of the respondents. Radiator repairers (5.28µg/L) recorded the highest urine lead level, followed by Battery charging specialist (4.96µg/L), Spray painters (4.44µg/L) and then Mechanics (3.53µg/L). Autoelectricians recorded the least mean urine lead level of 1.94µg/L. Pearson's chi-square test also showed a significant association between job specialty and the categorical urine lead level (Table 4.3).

Table 4.3: Association between of Urine Lead Level and Job Specialty of Respondents

Variables			Urine lead level (μg/L)					
		P-value	<1.00	1.00-3.99	4.00-6.99	7.00-11.60	Chi-square	P-value
	Mean ± SD		n (%)	n (%)	n (%)	n (%)		
Job specialty		<0.001*** F					52.84	<0.001***
Mechanic	3.53 ± 2.95		12 (27.27)	15 (34.09)	10 (22.73)	7 (15.91)		
Spray painter	4.44 ± 3.09		4 (13.33)	10 (33.33)	9 (30.00)	7 (23.33)		
Battery charger	4.96 ± 3.37		2 (6.06)	15 (45.45)	7 (21.21)	9 (27.27)		
Auto electrician	1.94 ± 2.45		29 (51.79)	19 (33.93)	4 (7.14)	4 (7.14)		
Radiator repairer	5.28 ± 2.68		2 (5.41)	8 (21.62)	15 (40.54)	12 (32.43)		

SD: standard deviation. n: frequency. %: row percentage. F: One-way ANOVA test. T: T-test. *: p<0.05. **: p<0.01. ***: p<0.001.

4.6 Association between Urine Lead Level and Demographic Characteristics of Respondents

Table below shows the association between urine lead level and demographic characteristics of respondents. The mean urine lead level in all 200 respondents was 3.78µg/L with a standard deviation of 3.12µg/L. About a quarter (24.5%) of the respondents had urine lead level below 1.00µg/L and a third (33.5%) had urine lead level between between 1.00 µg/L and 3.99 µg/L inclusive. 22.5% of them had urine lead level between 4.00 µg/L and 6.99 µg/L and about a fifth (19.5%) had urine lead level of 7.00 µg/L or more.

The mean distribution of Urine lead level was significantly different among the age group (p-value = 0.02) from the One-Way ANOVA test. The mean urine lead level was significantly higher among respondents in the age group of 46 - 60 (4.08µg/L) compared to those in the age group of 31 - 45 (3.90µg/L) and age group of 18 - 30 (1.84µg/L). Also, the t-test shows that the mean urine level among current smokers was significantly higher compared to the mean urine level among non-current smokers (6.59µg/L vs. 2.99µg/L, p-value <0.001).

The Pearson chi-square test of association also shows a significant association between the current smoking status of respondents and their urine lead level (χ^2 = 43.26, p-value <0.001).

Table 4.4: Test of Association between Urine Lead Level and Demographic Characteristics of Respondents.

Variables	P-value	<1.00	1.00-3.99	4.00-6.99	7.00-11.60	Chi-square	P-value	Mean ± SD
			Urine lead level (µg/L)					
			n (%)	n (%)	n (%)	n (%)		
Overall	3.78 ± 3.12		49 (24.50)	67 (33.50)	45 (22.50)	39 (19.50)		
Socio-demographic factors								
Age group		0.02*^{F}					11.90	0.064
18 – 30	1.84 ± 2.19		9 (50.00)	7 (38.89)	1 (5.56)	1 (5.56)		
31 – 45	3.90 ± 3.25		28 (25.45)	34 (30.91)	25 (22.73)	23 (20.91)		
46 – 60	4.08 ± 2.98		12 (16.67)	26 (36.11)	19 (26.39)	15 (20.83)		
Marital status		0.73^{T}					0.24	0.971
Married	3.65 ± 3.11		14 (26.92)	17 (32.69)	11 (21.15)	10 (19.23)		
Single	3.83 ± 3.14		35 (23.65)	50 (33.78)	34 (22.97)	29 (19.59)		
Educational level		0.074^{F}					12.75	0.174
None	4.30 ± 3.07		5 (21.74)	8 (34.78)	4 (17.39)	6 (26.09)		
Primary	4.10 ± 3.40		17 (28.33)	16 (26.67)	14 (23.33)	13 (21.67)		
JHS	2.89 ± 2.85		20 (33.90)	22 (37.29)	9 (15.25)	8 (13.56)		
SHS	4.15 ± 2.99		7 (12.07)	21 (36.21)	18 (31.03)	12 (20.69)		
Religion		0.314^{T}					1.75	0.627
Christians	3.61 ± 3.02		32 (25.60)	42 (33.60)	30 (24.00)	21 (16.80)		
Muslims	4.08 ± 3.28		17 (22.67)	25 (33.33)	15 (20.00)	18 (24.00)		

Life Style factors ***Currently smoking***		<0.001*** ^{T}					43.26	<0.001***
Yes	6.59 ± 2.72		0 (0.00)	10 (22.73)	12 (27.27)	22 (50.00)		
No	2.99 ± 2.76		49 (31.41)	57 (36.54)	33 (21.15)	17 (10.90)		
Takes alcohol		0.711 ^{T}					3.17	0.366
Yes	3.98 ± 2.77		4 (16.00)	10 (40.00)	8 (32.00)	3 (12.00)		
No	3.75 ± 3.17		45 (25.71)	57 (32.57)	37 (21.14)	36 (20.57)		

SD: standard deviation. n: frequency. %: row percentage. F: One-way ANOVA test. T: T-test. *: p<0.05. **: p<0.01. ***: p<0.001.

4.7 Association between Urine Lead Level and Work-Related Activities of Respondents

The t-test was used to test equality of mean urine level between respondents who perform certain work-related activities and those who did not. Respondents who picked their noses (4.33µg/L vs. 3.20µg/L, p-value = 0.009) and those who use snuff (6.48µg/L vs. 3.61µg/L, p-value = 0.020) had significantly higher mean urine level compared to those who did not (Table 4.5).

Respondents who washed their hands before meals (3.29µg/L vs. 4.90µg/L, pvalue=0.001), baths just after work (2.46µg/L vs. 4.08µg/L, p-value=0.002), uses PPEs (2.73µg/L vs. 5.18µg/L, p-value<0.001) and those who take breaks during work (2.49µg/L vs. 4.70µg/L, p-value<0.001) had significantly lower mean urine level compared to those who did not perform such activities. (Table 4.5)

Pearson‘s chi-square shows a significant association between urine lead level and usage of snuff (χ^2=12.65, p-value=0.005), washing of hands before meals (χ^2=15.36, p-value=0.002), bathing just after work (χ^2=9.98, p-value=0.019), the use of PPEs (χ^2=29.86, p-value<0.001) and taking of breaks during work periods (χ^2=30.19, pvalue<0.001). Table 4.5

Table 4.5: Test of Association between Urine Lead Level and Work-Related Activities of Respondents

Variables	Mean ± SD	P-value	Urine lead level (µg/L) <1.00 n (%)	1.00-3.99 n (%)	4.00-6.99 n (%)	7.00-11.60 n (%)	Chi-square	P-value
Occupational factors								
Number of years on work		0.554 [T]					1.86	0.603
<10 years	3.38 ± 3.10		5 (26.32)	8 (42.11)	2 (10.53)	4 (21.05)		
>10 years	3.82 ± 3.13		44 (24.31)	59 (32.6)	43 (23.76)	35 (19.34)		
Use PPEs		<0.001*** [T]					29.86	<0.001***
Yes	2.73 ± 2.68		41 (35.96)	41 (35.96)	21 (18.42)	11 (9.65)		
No	5.18 ± 3.13		8 (9.30)	26 (30.23)	24 (27.91)	28 (32.56)		
Breaks during work		<0.001*** [T]					30.19	<0.001***
Yes	2.49 ± 2.64		36 (43.37)	25 (30.12)	14 (16.87)	8 (9.64)		
No	4.70 ± 3.12		13 (11.11)	42 (35.90)	31 (26.50)	31 (26.50)		
Hygiene Practices								
Wash hands before meals		0.001** [T]					15.36	0.002**
Yes	3.29 ± 2.98		41 (29.5)	52 (37.41)	25 (17.99)	21 (15.11)		
No	4.90 ± 3.18		8 (13.11)	15 (24.59)	20 (32.79)	18 (29.51)		
Baths just after work		0.002** [T]					9.98	0.019*
Yes	2.46 ± 2.57		16 (43.24)	11 (29.73)	7 (18.92)	3 (8.11)		

No	4.08 ± 3.16		33 (20.25)	56 (34.36)	38 (23.31)	36 (22.09)		
Pick nose while working		0.009** [T]					7.58	0.055
Yes	4.33 ± 3.23		20 (19.42)	32 (31.07)	24 (23.3)	27 (26.21)		
No	3.20 ± 2.90		29 (29.9)	35 (36.08)	21 (21.65)	12 (12.37)		
Lifestyle factors								
Use "Snuff" during work		0.020* [T]					12.65	0.005**
Yes	6.48 ± 3.62		1 (8.33)	3 (25.00)	1 (8.33)	7 (58.33)		
No	3.61 ± 3.02		48 (25.53)	64 (34.04)	44 (23.4)	32 (17.02)		
Number eating times at work		0.627 [F]					6.33	0.387
Once	2.55 ± 2.70		1 (20.00)	3 (60.00)	1 (20.00)	0 (0.00)		
Twice	3.93 ± 3.02		13 (18.84)	28 (40.58)	13 (18.84)	15 (21.74)		
Thrice	3.75 ± 3.20		35 (27.78)	36 (28.57)	31 (24.60)	24 (19.05)		
Source of food		0.235 [T]					7.54	0.057
Vendors	4.46 ± 2.57		1 (3.85)	12 (46.15)	8 (30.77)	5 (19.23)		
Workshop canteen	3.68 ± 3.19		48 (27.59)	55 (31.61)	37 (21.26)	34 (19.54)		
How often fish is eaten at work		0.122 [F]					10.78	0.291
Never	4.93 ± 4.55		0 (0.00)	3 (60.00)	0 (0.00)	2 (40.00)		
Once/month	3.26 ± 2.84		28 (28.00)	37 (37.00)	22 (22.00)	13 (13.00)		
Once/week	4.24 ± 3.29		14 (24.14)	15 (25.86)	14 (24.14)	15 (25.86)		

Yes			14 (42.42)	10 (30.30)	5(15.15)	4 (12.12)		
No			35 (20.96)	57 (34.13)	40 (23.95)	35 (20.96)		
Once/day	4.32 ± 3.26		7 (18.92)	12 (32.43)	9 (24.32)	9 (24.32)		
Awareness of lead exposure		0.036*[T]					7.36	0.061
	2.69 ± 3.17							
	4.00 ± 3.07							

4.8 Association between Urine Lead Level and Self-Reported Health Symptoms among Respondents

Table 4.6 shows the association between urine lead level and self-reported health symptoms of the respondents. The mean urine lead level among respondents who reported to have hypertension, Chest pains, Heart palpitation, Low libido, Reduced sperm count, Anemia, Headache, Dullness, Muscular tremor, Loss of memory, poor attention span, Irritability, Stuff nose rhinitis, chest tightness and wheezing had significantly higher compared to the mean urine lead levels of those who did not have such symptoms (p-values <0.05).

Hypertension Yes No	5.97 ± 3.02 3.32 ± 2.95	<0.001*** T		(17.14) (36.97)	(37.14) (19.39)	(37.14) (15.76)	18.60	<0.001***
Chest pain Yes No	5.48 ± 2.73 3.40 ± 3.08	<0.001*** T	(8.57) (27.88)	(27.03) (34.97)	(35.14) (19.63)	(32.43) (16.56)	14.44	0.002**
Heart palpitation Yes No	5.60 ± 2.96 2.98 ± 2.85	<0.001*** T	(5.41) (28.83)	(22.95) (38.13)	(34.43) (17.27)	(36.07) (12.23)	32.35	<0.001***
Low libido Yes No	5.07 ± 3.16 2.87 ± 2.76	<0.001*** T	(6.56) (32.37)	(33.73) (33.33)	(27.71) (18.80)	(30.12) (11.97)	24.87	<0.001***
Infertility Yes No	5.37 ± 2.42 3.75 ± 3.13	0.271 T	(8.43) (35.90)	(25.00) (33.67)	(25.00) (22.45)	(50.00) (18.88)	3.05	0.385
Reduced sperm count Yes No	5.52 ± 2.14 3.69 ± 3.14	0.025* T	(0.00) (25.00)	(30.00) (33.68)	(30.00) (22.11)	(40.00) (18.42)	5.15	0.161
Abnormal prostatic function Yes No	7.77 ± 2.22 3.74 ± 3.11	0.216 T	(0.00) (25.79)	(0.00) (33.84)	(50.00) (22.22)	(50.00) (19.19)	2.81	0.421
Anemia Yes No	4.72 ± 2.95 3.48 ± 3.13	0.013* T	(0.00) (24.75)	(34.69) (33.11)	(28.57) (20.53)	(26.53) (17.22)	8.15	0.043*
Headache Yes	4.24 ± 3.20 3.14 ± 2.91	0.012* T	(10.20) (29.14)	(37.61) (27.71)	(24.79) (19.28)	(22.22) (15.66)	12.71	0.005**
			(15.38)					

No	(37.35)

Table 4.6: Test of Association between Urine Lead Level and Self-Reported Symptoms among Respondents

Variables	Urine lead level (µg/L)						Chi-square	P-value
	Mean ± SD	P-value	<1.00 n (%)	1.00-3.99 n (%)	4.00-6.99 n (%)	7.00-11.60 n (%)		

Dullness		<0.001*** T					44.66	<0.001***
Yes	5.67 ± 2.92		4 (5.48)	17 (23.29)	26 (35.62)	26 (35.62)		
No	2.70 ± 2.69		45 (35.43)	50 (39.37)	19 (14.96)	13 (10.24)		
Muscular tremor		<0.001*** T					40.19	<0.001***
Yes	5.43 ± 3.06		5 (6.02)	25 (30.12)	24 (28.92)	29 (34.94)		
No	2.61 ± 2.60		44 (37.61)	42 (35.9)	21 (17.95)	10 (8.55)		
Loss of memory		<0.001*** T					45.79	<0.001***
Yes	7.60 ± 2.29		0 (0.00)	2 (7.69)	7 (26.92)	17 (65.38)		
No	3.21 ± 2.82		49 (28.16)	65 (37.36)	38 (21.84)	22 (12.64)		
Poor attention span		<0.001*** T					18.59	<0.001***
Yes	5.86 ± 2.77		0 (0.00)	8 (26.67)	10 (33.33)	12 (40.00)		
No	3.42 ± 3.04		49 (28.82)	59 (34.71)	35 (20.59)	27 (15.88)		
Irritability		<0.001*** T					27.59	<0.001***
Yes	5.76 ± 3.12		4 (7.41)	14 (25.93)	14 (25.93)	22 (40.74)		
No	3.05 ± 2.79		45 (30.82)	53 (36.3)	31 (21.23)	17 (11.64)		
Asthmatic attacks		0.223 T					5.50	0.139
Yes	4.67 ± 3.15		1 (5.56)	9 (50.00)	3 (16.67)	5 (27.78)		
No	3.69 ± 3.11		48 (26.37)	58 (31.87)	42 (23.08)	34 (18.68)		
Stuff nose rhinitis		<0.001*** T					15.82	0.001**
Yes	4.58 ± 3.06		13 (14.13)	28 (30.43)	29 (31.52)	22 (23.91)		

No	3.10 ± 3.02		36 (33.33)	39 (36.11)	16 (14.81)	17 (15.74)		
Chest tightness		<0.001***[T]					38.69	<0.001***
Yes	7.65 ± 2.07		0 (0.00)	1 (4.76)	6 (28.57)	14 (66.67)		
No	3.33 ± 2.91		49 (27.37)	66 (36.87)	39 (21.79)	25 (13.97)		
Cough/sore throat		0.167[T]					4.74	0.192
Yes	5.53 ± 2.38		0 (0.00)	1 (20.00)	3 (60.00)	1 (20.00)		
No	3.74 ± 3.13		49 (25.13)	66 (33.85)	42 (21.54)	38 (19.49)		
Wheezing or whistling sounds		<0.001***[T]					27.18	<0.001***
Yes	6.50 ± 2.61		0 (0.00)	7 (21.21)	11 (33.33)	15 (45.45)		
No	3.24 ± 2.93		49 (29.34)	60 (35.93)	34 (20.36)	24 (14.37)		

SD: standard deviation. n: frequency. %: row percentage. F: One-way ANOVA test. T: T-test. *: p<0.05. **: p<0.01. ***: p<0.001.

4.9 Multiple Linear Regression Model of the distribution of Urine Lead Levels among Respondents

The multiple linear regression was fitted to determine the net difference in mean urine level among the characteristics of the respondents in table 6.

The adjusted mean urine lead level was significantly higher by 0.96μg/L (95% CI: 0.07 to 1.86 μg/L, p-value=0.035) for current smokers than non-current smokers. Also, the adjusted mean urine lead level was significantly higher by 1.42μg/L (95% CI: 0.01 to 2.82 μg/L, p-value = 0.048) for respondents who use ―Snuff‖ during work than those who did not use. Respondents who wash their hands before meals at the workplace had an adjusted mean urine level of 0.67 μg/L (95% CI:-1.26 to -0.08 μg/L, p-value=0.026) significantly lower than those who do not wash their hands before meals at the workplace. Also, respondents who use PPEs had adjusted mean urine levels of 0.29μg/L (95% CI: -1.27 to -0.07 μg/L, p-value=0.030) significantly lower compared to those who did not use PPEs.

Radiator repairers had the highest adjusted mean urine level. Mechanics had an adjusted mean urine level of 1.04μg/L (95% CI: -1.99 to -0.08 μg/L, p-value 0.034) compared to radiator repairers. Auto-electricians also had adjusted mean urine level of 1.00μg/L (95% CI: -1.88 to -0.13 μg/L, p-value=0.024) significantly lower than radiator repairers.

Table 4.7: Multiple Linear Regression Model of the distribution of Urine Lead Levels among Respondents

Variables	aβ (μg/L)	95% CI (μg/L)	P-value
Age group			
18 - 30	(ref)		
31 - 45	0.59	(0.00, 1.19)	0.051
46 - 60	0.37	(-0.25, 1.00)	0.238

Smokes (ref: No)	0.96	(0.07, 1.86)	0.035*
Picks nose during work (ref: No)	0.35	(-0.15, 0.86)	0.172
Uses "Snuff" during work (ref: No)	1.42	(0.01, 2.82)	0.048*
Wash hands before meals (ref: No)	-0.67	(-1.26, -0.08)	0.026*
Baths just after work (ref: No)	-0.14	(-0.66, 0.38)	0.591
Uses PPEs (ref: No)	-0.67	(-1.27, -0.07)	0.030*
Have breaks during work (ref: No)	-0.29	(-0.85, 0.28)	0.321
Job specialty Radiator repairer	(ref)		
Mechanic	-1.04	(-1.99, -0.08)	0.034*
Spray painter	-0.75	(-1.78, 0.27)	0.149
Battery charger	-0.64	(-1.52, 0.24)	0.155
Auto electrician	-1.00	(-1.88, -0.13)	0.024*
Self-reported symptoms			
Headache (ref: No)	-0.22	(-0.77, 0.34)	0.440
Rhinitis catarrh (ref: No)	0.50	(-0.01, 1.00)	0.056
Low libido (ref: No)	0.62	(-0.07, 1.30)	0.076
Muscular tremor (ref: No)	0.71	(0.07, 1.35)	0.030*
Dullness (ref: No)	0.92	(0.22, 1.62)	0.010*
Heart palpitations (ref: No)	0.83	(0.19, 1.47)	0.012*
Irritability (ref: No)	0.94	(0.32, 1.56)	0.003**
Anemia (ref: No)	0.25	(-0.39, 0.88)	0.442
Chest pain (ref: No)	0.13	(-0.60, 0.86)	0.727
Hypertension (ref: No)	0.38	(-0.38, 1.13)	0.327
Wheezing/whistling sound (ref: No)	1.35	(0.43, 2.27)	0.004**
Poor attention span (ref: No)	0.85	(0.15, 1.55)	0.018*
Loss of memory (ref: No)	1.47	(0.54, 2.41)	0.002**
Chest tightness (ref: No)	1.70	(0.85, 2.55)	<0.001***
Reduced sperm count (ref: No)	-0.81	(-2.03, 0.41)	0.191

aβ: adjusted coefficient (difference). CI: confidence interval. *: $p<0.05$. **: $p<0.05$. ***: $p<0.001$. ref: reference category.

CHAPTER FIVE

DISCUSSIONS

5.1 Summary of Major Findings

Demographically, the study indicated that majority of the study population were quiet matured with 31 – 45years age group being the most predominant accounting for 55%

of the total sampled, while the 18 – 30 years age group were the least encountered (9%). The gender distribution in the study was predominantly male dominated with the adherents of the Christian faith (62.5%) being dominant followed by the Muslims (37.5%). The dominance of males in the auto technician trade is not surprising as it is physically tasking; Salui*et al*., (2015) and Oluwagbemi (2007) made similar findings while Alayande (2000) reported few females in his study. The literacy level among the sampled group was 88.5% with JHS holders accounting for 29.5%, SHS graduates (29%), primary school leavers (30%), whereas 11.5% respondents had no education. The study indicated that the majority of respondents (n=175) representing 87.5% do not drink alcohol while 25 respondents (12.5%) reported that they drink. The results on the distribution of respondents on smoking disposition shows that the majority of respondents (n=156) representing 78% do not smoke while 44 respondents (22%) reported that they smoke.

The distribution of job specialty among the respondents showed dominance by Auto electricians 28.0%, followed by Mechanics 22.0% (n=44), 19.0% (n=38) were Radiator repairer and 16.0% (n=32) were Battery chargers while spray painters 15% (n=30) were the least encountered in the study. Radiator repairers (5.28µg/L) recorded the highest urine lead level whereas Auto-electricians recorded the least mean urine lead level of 1.94µg/L.

The study revealed the prevalence of self-reported health symptoms experienced by respondents. Headache (58.5%), Rhinitis catarrh (46.0%), Muscular tremor (41.5%) and Low Libido (41.5%) were the most experienced health symptoms reported by the respondents. Cough with sputum production (0.5%) abnormal prostatic function (1.0%) and infertility (2.0%) were the least self-reported health symptoms among the study participants. The study showed that the awareness of the study population on the danger of Lead (Pb) exposure was quite low with (n=167) representing 83.5% ignorant of the danger of Lead (Pb) exposure to their health.

The study also revealed that majority of the sampled population were quite experienced on their jobs with more than 90% of them having been on their jobs for over 10 years. Jinadu (1982) made similar findings in South West Nigeria. According to this study, the use of Personal Protective Equipment's (PPE) was fairly good among study subjects with 57% of them using some kind of PPE. Omokhodion FO.
1999, in his studies made contradicting findings where the use of PPE's was very low among workers.

The determinants of Pb exposure among automobile technicians according this study were; awareness of Pb hazards, occupational factors, practice of personal hygiene and lifestyle factors and social demographic factors

5.2. Discussion

5.2.1 Urine Pb levels among Automobile Technicians

In achieving one of the specific objectives of the study which is to determine the urine lead (Pb) levels of automobile technicians in the study area, the study showed that the mean urine lead levels in all 200 respondents were 3.78µg/L with a standard deviation of 3.12µg/L. About a quarter (24.5%) of the respondents had urine lead level below

1.00µg/L and a third (33.5%) had urine lead level between 1.00 µg/L and 3.99 µg/L inclusive. 22.5% of them had urine lead level between 4.00 µg/L and 6.99 µg/L and about a fifth (19.5%) had urine lead level of 7.00 µg/L or more. Nonetheless, all the readings are within the recommended level of < 20µg/L for individuals aged 16 years and above (CDC, 2006).

5.2.2 Urine Pb levels among various job specialties and factors affecting exposure

To address the specific objective of comparing the measured urine lead (Pb) levels of automobile technicians in various job specialties, the study revealed a significantly diverse urine lead (Pb) levels among automobile technicians. The One-way ANOVA test shows that the mean urine lead level was significantly different between the various job specialties of the respondents. Radiator repairers (5.28µg/L) recorded the highest urine lead level, followed by Battery charging specialist (4.96µg/L), Spray painters (4.44µg/L) and then Mechanics (3.53µg/L). Auto-electricians recorded the least mean urine lead level of 1.94µg/L. Pearson‘s chi-square test also showed a significant association between job specialty and the categorical urine lead level.

Factors like age, smoking of cigarette, the use of snuff, practice of good personal hygiene, the use of PPEs and observation of breaks during working hours were the major factors the influence Pb exposure among automobile technicians. The study also showed the equality of mean urine lead level between respondents who perform certain work-related activities and those who did not. Respondents who picked their noses (4.33µg/L vs. 3.20µg/L, p-value = 0.009) and those who use snuff (6.48µg/L vs. 3.61µg/L, p-value = 0.020) had significantly higher mean urine lead level compared to those who did not. Respondents who washed their hands before meals (3.29µg/L vs. 4.90µg/L, p-value=0.001), baths just after work (2.46µg/L vs. 4.08µg/L, p-value=0.002), uses PPEs (2.73µg/L vs. 5.18µg/L, p-value<0.001) and those who take breaks during work (2.49µg/L vs. 4.70µg/L, p-value<0.001) had significantly lower mean urine lead level compared to those who did not perform such activities.

The frequency of smoking on duty by automobile technicians was found to be very low (12.5%). There was a similar findings presented by (NIOSH, 1978, Rose et *al.*, 1987 and Alayande, 2000) where smoking during work was low among respondents. Nonetheless, the mean urine level among current smokers was significantly higher compared to the mean urine level among non-current smokers (6.59µg/L vs. 2.99µg/L, p-value <0.001). (Table 2) This finding confirms the fact that; the degree of uptake of lead from the respiratory tract is boosted by smoking habit (Karita *et al.*, 2005). Pearson‘s chi-square shows a significant association between urine lead level and usage of snuff (χ^2=12.65, p-value=0.005), washing of hands before meals

(χ^2=15.36, p-value=0.002), bathing just after work (χ^2=9.98, p-value=0.019), the use of PPEs (χ^2=29.86, p-value<0.001) and taking of breaks during work periods (χ^2=30.19, p-value<0.001). (Table 4)

5.2.3 Association between Urine Pb levels and prevalence of self-reported health symptoms

Lead (Pb) has no known physiological role in the human but following exposure, its damaging effects is manifold (Wolf *et al*., 2007; Rubin & Strayer, 2008). In an occupational context, the _no effect‘level (NOEL) of lead exposure is being observed as increasingly sensitive measures of the physiological effects of lead are developed (Lewis R, 1997). This study revealed the prevalence of self-reported health symptoms experienced by respondents. The study showed the association between urine lead level and self-reported health symptoms of the respondents. The mean urine lead level among respondents who reported to have hypertension, Chest pains, Heart palpitation, Low libido, Reduced sperm count, Anemia, Headache, Dullness, Muscular tremor, Loss of memory, poor attention span, Irritability, Stuff nose rhinitis, chest tightness and wheezing had significantly higher compared to the mean urine lead levels of those who did not have such symptoms (p-values <0.05) as shown in (Table 5). This findings is in line with the claim that, at lower exposure level (<40 µg/L), Pb have less severe effects on the neurological behavioral effects following Pb exposure. Some of these effects include; reduced libido, depression/mood changes, dizziness, headache, fatigue, impaired concentration, irritability, impotence, forgetfulness and lethargy. Nonetheless, effects on the cardiovascular, respiratory and reproductive system were also reported by respondents in.

5.3 Validity of Method

Automobile technicians who execute their task at the magazine where samples were drawn for the study had a high participation rate therefore, minimizing selection bias. Data on Pb exposure was collected objectively and subjectively and findings on the urine Pb levels and prevalence of self-reported health symptoms experienced were the same. Hence, the effect of information bias in this study was minimal. The study population was homogeneous with regard to culture and by socio-economic status, reducing the potential effect of unmeasured confounding. Again, to the researcher, this is the first study in Ghana in identifying the risk factors to Pb exposure among automobile technicians.

5.4 Study Limitation

This study was aimed at identifying the risk factors that predispose automobile technicians in the Sunyani Magazine to lead (Pb). Cooperation from the technicians to willingly participate in the study was very low because of some believes. Most of the technicians has this superstitious believe that anything related with human blood and urine could be used for evil purposes, hence some did not avail themselves for sample collection. Time limitation on the part of the technicians due to the nature of their work was also a hindrance to the smooth running of data collection. Again, the crosssectional design restricted the ability to discern any temporality.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study to identify the risk factors that predispose automobile technicians in the Sunyani Magazine in the Brong Ahafo Region of Ghana to lead (Pb) indicated a reproductive age group that is gender biased and predominantly male, literate but with limited knowledge on the hazards of exposure to lead (Pb).This study has provided an insight into the lead exposure levels of automobile technicians in the study area. All measured urine Pb levels of subjects were found to be within recommended ranges. The mean urine lead level in all 200 respondents was 3.78µg/L with a standard deviation of 3.12µg/L. Majority of the respondents were auto electricians, followed by general mechanics, radiator repairers, and battery chargers while spray painters were the least automobile technicians encountered. The study reported on the prevalence self-reported health symptoms by respondents. Headache (58.5%), Rhinitis catarrh (46.0%), Muscular tremor (41.5%) and Low Libido (41.5%) were the most experienced health symptoms reported by the respondents whereas Cough with sputum production (0.5%) abnormal prostatic function (1.0%) and infertility (2.0%) were the least self-reported health symptoms among the study participants.

Occupationally related factors were the major factors that put automobile technician at risk of Pb exposure hence there is the need for various control measures such as training and health education as fundamental means in the prevention of lead exposures in automobile technicians. It is vital to recognize that in addition to related research, better health promotion and safety measures should be given to automobile technicians in Sunyani Municipality Magazine. There is therefore the need for better protection of the health of automobile technicians from lead exposure and poisoning.

6.2 Recommendations

Based on the findings of the study, the following recommendations are offered;

- Institute a health surveillance programme comprising of health education and training on health hazards of automobile works, personal protection measures as well as periodic health screening for early detection of adverse health effects of exposure to hazards in the automobile work in the Sunyani Magazine area.
- There is a need for Ghana to adopt and develop a broad based Occupational Safety and Health policy and integrate that with the ILO convention 155 as a minimum to have a unitary framework that addresses occupational safety and health across various economic sectors in the country.
- Sustained media dissemination of the key objectives of the proposed consolidated Occupational Safety and Health policy in both print and electronic media.
- Periodic monitoring, evaluation, and enforcement of standards and compliance to the policy with the view to promptly remedy deviations and punitive measures meted out to non-conformers.
- Intensify campaign on the ban importation of leaded petrol into the country so as to reduce the amount of organic lead exposure.
- Improved and sustained actions should be directed at minimizing exposures, improving work ethics and practices and encouraging the use of personal protective equipment.
- Future studies should incorporate blood lead (Pb) levels measurements along with the urine lead (Pb) levels to provide a more holistic picture of the extent of exposure.

The workers should:

a. Protect themselves against occupational lead exposures.

b. Report promptly any defects in the course of work to competent supervisor.

c. Comply with safety procedures relating to prevention and control of lead.

d. Carry out correct work practices by obeying health instructions.

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APPENDICES

Appendix 1: A sample of the questionnaire issued to the subjects

QUESTIONNAIRE

This questionnaire is aimed at eliciting information, which will facilitate completion and writing of a thesis report as part of a Master of Science degree program. It will also assist in policy formulation concerning environmental exposures that may affect the health of automobile technicians. The information that will be given to me will be treated in strict confidence and the identity of the respondent will not be disclosed under whatever circumstances. Please feel free and give appropriate answers as sincere as possible.

Thank you.

A. <u>Personal Data</u>

Participant ID Number ……………….

1. Age …….………..........

2. Zone…………………

3. Marital Status; Married [ ] Single [ ] Divorced [ ]

4. Religion; Christian [ ] Muslim [ ] ATR [ ] Other [ ]

5. Place of residence …………………………

6. Level of education: No formal education [ ]Primary school [ ] Junior High [ ] Secondary / Technical school [ ]Diploma/ degree [ ]

B. Occupational history, Health & Safety and Exposure to Pb

7. Type of work or job speciality;

Mechanics [ ]
Spray Painter [ ]
Battery Charger [ ]

Auto electrician [ ]
Radiator Repairer [ ] 8.
Number of years on the job?

<1 year [ ]
1-2 years [ ]
2-5 years [ ]
5-10 years [ ]
>10 years [ ]

9. Number of hours on the job in week.

<1 hr. [ ] 6-8 hrs. [ ]

2-4 hrs. [ ] 8-10 hrs.[ ]

4-6 hrs.[ ] >10 hrs. [ ]

10. Do you use protective devices during working hours? Yes [ ] No[ ]

11. If yes, which one?

Overall [ ] Eye goggles [ ] Respirator [ ]

Hand gloves [ ] Nose mask [ ]

Boots [ ] Ear muffs [ ]

12. If yes, in 10 above, how often do you use the protective device? Never [ ] Occasionally [ ] Always [ ]

13. How often do you wash or change this working gear?
Daily [ ] Every 2 weeks [ ]

Weekly [ ] Monthly [ ]

14. If you don‘t use a PPE, why?

It‘s expensive [ ] Don‘t know where to get them [ ]

Not necessary [ ] It‘s uncomfortable [ ] 15.
Do you have breaks during working hours? Yes [ ] No [ ]
16. If yes, how long is your break?
<1 hr. [ ]
1-2 hrs. [ ]
2-3hrs. [ ]
17. Are you aware of lead exposure as a hazard in your work? Yes [ ] No[ ]

18. Are you exposed to fumes/dust from the work that you do? Yes [ ] No [ ]
19. If ―yes‖. What do you do to reduce your lead exposure?

Washing hands often especially before eating. Yes [ ] No [ ]

Having shower on completion of activity. Yes [ ] No [ ]

Change cloths upon completion of the work activity. Yes [ ] No [ ]

The use of PPE‘s. Yes [ ] No [ ]

20. Are you aware any of these behaviours can result in disease?

Sucking fuel: Yes [ ] No [ ] Do not know [ ]

Washing hands with fuel: Yes [ ] No [ ] Do not know [ ]

Not using protective devices: Yes [ ] No [ ] Do not know [ ]

Inhaling fumes from vehicle exhaust: Yes [ ] No [ ] Do not know [ ]

Non washing of hands before eating at work: Yes [ ] No [ ] Do not know[ ]

21. Do you operate or work in a well-ventilated shop/environment? Yes [ ] No [ ]
22. Did you get training for the job you are currently doing? Yes [ ] No [ ]

B. Personal, Social and Eating habits

23. Do you drink alcohol? Yes [ ] No [ ]

24. If yes how often do you take alcohol?

At least once a day [ ] At least once each day [ ] At least once a month [ ]

25. Do you smoke? Yes [ ] No [ ]
26. If yes in the question above how often do you smoke?
1- 2 cigarettes per day) [ ]
3 – 4 cigarettes per day [ ]
5 and above cigarette per day [ ]

27. Do you normally wash your hands before eating?

Yes [ ] No [ ]

28. What do you use to wash your hands?

Water [ ] Petrol [ ]

Soap and Water [ ] Kerosene [ ]

29. Do you bath before going home after day work? Yes [ ] No [ ]
30. Do you use ―Asra‖ (Snuff) during working hours? Yes[ ]No [ ]
31. If yes to question 29 above, how often do you use it during working hours?
Every 30 minute [ ] Every hour [ ]
Every 2 hours [ ] whenever I get tired [ ]
32. Do you pick your nose more often during working hours? Yes [ ]No[ ]
33. Do you eat in or around your shop? Yes [ ] No [ ] 34. If yes how many times do you eat in a day at the shop?
1* daily [ ] 2* daily [ ] 3* daily [ ]
35. What is the source of food during working? Home [ ] Vendors [ ] Workshop Canteen [ ]
36. What type of food do you usually eat at the work place? ………………… 37. How close is the source of food to your shop?
10 – 20m [ ] 30m – 40m [ ]
50m – 60m [ ] 70m – 80m [ ]

90m – 100m [ ] Above 100m [ ]

38. Do you eat fish? Yes [ ]No[ ] 39. How frequently do you eat fish?

At least once a month [ ]At least once a week [ ] At least once a day [ ]

E. SELF-REPORTED SYMPTOMS/ DIAGNOSED HEALTH CONDITION

I would like to ask you about symptoms that you have had recently and in the past one year. Kindly answer them as accurately as you can. Thank you for your time!

KEY: 1=Once in a while 2=some of the time 3=Most of the time 4= All the time

CARDIOVASCULAR SYSTEM
In the past 1 year, have you ever had ...

1. a. High blood pressure (hypertension?) a. Yes [ ] b. No [ ] b .If yes in 1 above, how often?[1][2][3] [4]
2. a. Chest pain? a. Yes [ ] b. No [ ]
   b. If yes, how often?[1] [2][3] [4]
3. a. Heart palpitations? a. Yes [ ] b. No [ ]
   b. If yes, how often?[1] [2][3] [4]
4. Do you have any other form heart disorder? a. Yes [ ] b. No [ ]

REPRODUCTIVE SYSTEM
In the past 1 year, have you ever had ...

5. a. Low libido? a. Yes [ ] b. No [ ]
   b. If yes, how often?[1] [2][3] [4]
6. Have you been diagnosed with any of these conditions?
   - Abnormal spermatogenesis a. Yes [ ] b. No [ ]
   - Chromosomal damage. Yes [ ] b. No [ ]
   - Infertility a. Yes [ ] b. No [ ]
   - Abnormal prostatic function a. Yes [ ]b. No [ ]

NERVOUS SYSTEM
In the past 1 year, have you ever had ...

7. a. Anaemia? a. Yes [ ] b. No [ ]
   b. If yes, how often?[1] [2][3] [4]
8. Do you experience any of the following symptoms?

Dullness a. Yes [ ]b. No [ ]If yes, how often?[1] [2][3] [4]
Irritability a. Yes [ ]b. No [ ]If yes, how often?[1] [2][3] [4]
Headache a. Yes [ ]b. No [ ]If yes, how often?[1] [2][3] [4]
Muscular tremor a. Yes [ ]b. No [ ]If yes, how often?[1] [2][3] [4]
Loss of memory a. Yes [ ]b. No [ ]If yes, how often?[1] [2][3] [4]
Hallucinations a. Yes [ ] b. No [ ] If yes, how often?[1] [2][3] [4]
Poor attention span a. Yes [ ]b. No [ ]If yes, how often?[1] [2][3] [4]

RESPIRATORY SYSTEM
In the past 1 year, have you ever had ...

9. a. An asthmatic attack?a. Yes [ ] b. No [ ]
   b. If yes, how often?[1] [2][3] [4]
10. a. Metallic taste in the mouth?a. Yes [ ] b. No [ ]
    b. If yes, how often?[1] [2][3] [4]
11. a. Cough and /or sputum production on most days for more than 3 months?a. Yes [ ] b. No [ ]
    b. If yes, how often?[1] [2][3] [4]
12. a. Wheezing or whistling sound in the chest when breathing? a. Yes [ ] b. No [ ]
    b. If yes, how often? [1] [2][3] [4]
13. a. Stuffy nose/rhinitis /catarrh? a. Yes [ ] b. No [ ]
    b. If yes, how often? [1] [2][3] [4]
14. a. Cough/sore throat not caused by a cold lasting for ≥14 days? a. Yes [ ] b. No [ ]
    b. If yes, how often? [1] [2][3] [4]
15. a. Chest tightness lasting for ≥30 min? a. Yes [ ] b. No [ ]
    b. If yes, how often? [1] [2][3] [4]

Appendix 2: Informed Consent

Institutional Affiliation

KNUST-African Institute of Sanitation and Waste Management

Background

Dear participant, Luke Visser Donyina is my name, a student of the KNUST-African Institute of Sanitation and Waste Management. I am undertaking a study on EXPOSURE OF AUTO MOBILE TECHNICIANS TO LEAD IN THE SUNYANI MAGAZINE IN THE BRONG AHAFO REGION OF GHANA

The study will be aimed at identifying the risk factors that predispose automobile technicians in the Sunyani Magazine in the BrongAhafo Region of Ghana to lead (Pb).

Procedures

The study will involve answering questions from a structured questionnaire and urine sample taking. This is purely an academic research, which forms part of my work for the award of a master of environment and public health degree .I would be very grateful to have you as part of this study.

Risks and Benefits

The study will not cause any discomfort to participants. It is hoped that results obtained for this study will be used by policy makers and the community in particular to either improve upon existing safety measures or to enforce existing ones with the objective of protecting the auto technicians from the harmful effect of this toxic metal. **Right to refuse**

Participation in this study is voluntary and one can choose not to answer any particular question or all questions. You are at liberty to withdraw from the study at any time. However, it is encouraged that you to participate since your opinion is important in determining the outcome of the study.

Anonymity and Confidentiality

I would like to assure you that whatever information provided will be handled with strict confidentiality and will be used purely for the research purposes. Your responses will not be shared with anybody who is not part of the research team. Data analysis will be done at the aggregate level to ensure anonymity.Data collected cannot be linked to you in anyway. No name or identifier will be used in any publication or reports from this study. However, as part of our responsibility to conduct this research properly, we may allow officials from Ghana Standard Authority, Supervisors, and Committee on Human Research Publication and Ethics (CHPRE) of KNUST to have access to your records for 3-5 years upon completion of the research.

Dissemination of results

The result of this study will be sent to you if you provide your address below.

Before taking the consent, do you have any question you wish to ask about the study?

Yes (if yes, questions to be noted bellow)

No ……………………………………………………………………………………

If you have questions later, you may contact me on 0506902520.

Your rights as a Participant

Further, if you have any concern about the conduct of this study, your welfare or your rights as a research participant, you may contact:

The Office of the Chairman Committee on Human Research and Publication Ethics Kumasi Tel: 03220 63248 or 020 5453785

CONSENT FORM

Statement of person obtaining informed consent:

I have fully explained this research to ____ and have given sufficient information about the study, including that on procedures, risks and benefits, to enable the prospective participant make an informed decision to or not to participate.

DATE: _______________________ NAME: _____________________________________ **Statement of person giving consent:**

I have read the information on this study/research or have had it translated into a language I understand. I have also talked it over with the interviewer to my satisfaction.

I understand that my participation is voluntary (not compulsory).

I know enough about the purpose, methods, risks and benefits of the research study to decide that I want to take part in it.

I understand that I may freely stop being part of this study at any time without having to explain myself.

I have received a copy of this information leaflet and consent form to keep for myself.
NAME:____

DATE: _____________ SIGNATURE/THUMB PRINT: ____________________

Statement of person witnessing consent (Process for Non-Literate Participants):

I ____________________________ (Name of Witness) certify that information given to

_________________________________ (Name of Participant), in the local language, is a true reflection of what l have read from the study Participant Information Leaflet, attached.

WITNESS' SIGNATURE (maintain if participant is non-literate): ___________________

Interviewer's Statement

I, the undersigned, have explained this consent form to the subject in English or Twi that he/she understands the purpose of the study, procedures to be followed as well as risks and benefits involved. The subject has freely agreed to participate in the study.

Interviewer's signature…………………………

Date:……………..……………………………..

Address:…………..……………………………

Appendix 3: Copy of Approved Ethical clearance

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF HEALTH SCIENCES

SCHOOL OF MEDICAL SCIENCES / KOMFO ANOKYE TEACHING HOSPITAL
COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/464/17 — 2nd October, 2017.

Mr. Luke Visser Donyina
% Glory Prince of Peace Clinic
Post Office Box 163
KINTAMPO.

Dear Sir,

LETTER OF APPROVAL

Protocol Title: ***"Exposure of Auto Mobile Technicians to Lead among Adults in the Sunyani Magazine of Brong Ahafo Region, Ghana."***

Proposed Site: ***Sunyani Magazine.***

Sponsor: ***Principal Investigator.***

Your submission to the Committee on Human Research, Publications and Ethics on the above named protocol refers.

The Committee reviewed the following documents:

- A Completed CHRPE Application Form.
- Research Protocol.
- Occupational Data.

The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for a fixed period of one year, beginning 2nd October, 2017 to 1st October, 2018 renewable thereafter. The Committee may however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only. Permission should be sought from the Committee if any amendment to the protocol or use, other than submitted, is made of your research data.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever one comes first. It should also be informed of any publication arising from the study.

Yours faithfully,

Osomfo Prof. Sir J. W. Acheampong MD, FWACP
Chairman

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