2017

Safety Practices on Lead Poisoning Among Battery Technicians in Lagos Nigeria

Tajudeen Olusegun Rasheed
Walden University

Walden University

College of Health Sciences

This is to certify that the doctoral dissertation by

Tajudeen Rasheed

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Naoyo Mori, Committee Chairperson, Public Health Faculty
Dr. Xianbin Li, Committee Member, Public Health Faculty
Dr. Albert Terrillion, University Reviewer, Public Health Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2017

Abstract

Safety Practices on Lead Poisoning Among Battery Technicians in Lagos Nigeria

by

Tajudeen Olusegun Rasheed

MPH, Lagos State University, 2009

BS, Obafemi Awolowo University, 1993

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

August 2017

Abstract

Maintaining due diligence on safety practices at the workplace of battery technicians is the most cost-effective intervention against lead-related hazards. The safety practice on lead poisoning in Nigeria is below average, and the compliance level is far from the expected target of 90%. Using Dejoy's workplace self-protective behavior theory, this study investigated multilevel factors that influence safety practices on lead poisoning and compared the rate of utilization of personal protective equipment by battery technicians in the organized and roadside settings. The study was a quantitative, cross-sectional survey design, and a multistage and systematic sampling technique was used to select 293 adult battery technicians aged 18 years and above. Hypotheses were tested with chi-square and multivariate logistic regressions at the significant level of $p < 0.05$ and 95% confidence interval. The outcome of the safety practice status of battery technicians is 20%, and the rate of utilization of personal protective equipment is 18% in Lagos, Nigeria. Findings revealed that workplace conditions, blood lead levels, knowledge, education, and the rate of utilization of personal protective equipment are predictors of the safety practice status of battery technicians. There was no significant difference between battery technicians in the organized and roadside setting considering the perceived risk of lead poisoning and utilization of personal protective equipment. The positive social change implications of this study include recommendations for battery technicians to use the evolved alternative safety approaches to reduce lead-related hazards. Public health professional and policymakers should invest resources towards reducing the impact of lead poisoning on battery technicians at the workplace.

Safety Practices on Lead Poisoning Among Battery Technicians in Lagos Nigeria

by

Tajudeen Olusegun Rasheed

MPH, Lagos State University, 2009

BS, Obafemi Awolowo University, 1993

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

August 2017

Dedication

To God Almighty, I give glory for keeping me alive to the completion of this doctoral capstone work. I dedicate the work to Almighty Allah and to my mother, my wife, my children, family members, and friends who wished me well during my educational program. Finally, this work is also in memory of my late father, who died on the 10th of October 2015. I will always remember him for his passion for education.

Acknowledgements

Praised be to Almighty God, the most merciful and the most beneficent,for enablingand making it possible for me to be part of this laudable Ph.D. Public Health program. I wish to thank Ms. Christiana Omole for her encouragement and assurance during my enrollment; you area good ambassador of the institution. I am particularly indebted to my dissertation supervisory committee chair, Dr. Naoyo Mori; she is an excellent mentor who offered valuable critique throughout the work. She sacrificed her precious time to ensure the successful completion of the study. She was always patient with me and displayed high professionalism in guiding my dissertation process. I thank the dissertation supervisory committee member, Dr. Xianbin Daniel Li, for his support and offering of excellent professional input to the study throughout the dissertation process. Dr. Albert J. Terrillion, the University Research Representative (URR) is equally professional; thank you for the support on my dissertation.

I am grateful to the public health program director and the reviewers of my prospectus; you are all professional. I also thank Gregory P. Hickman, Ph.D.; I appreciate your mentorship. I thank all the instructors that facilitated my course work, the IRB team, the dissertation quality reviewers, and Chief Academic Officer/Designee for their contribution towards completion of this work. My appreciation goes to all battery charging technicians who participated in this study in Lagos, Nigeria. Lastly, I am grateful to my wife (Rukayat Ololade Abdul-Rasheed, *MLS*, *ACIS*, *MBA*), and my children (AbdulQuadri Opeyemi, Aminat Oluwatomi, Abdullah Oluwatimilehin, and Ali Oladotun) for their support, understanding, sacrifices, prayer, and perseverance throughout my doctoral program.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction to the Study

Lead (Pb) is found in soils, plants, and water in a natural form and is one of the most widely scattered toxic metals in the world (Rogers et al. 2014). The diverse sources of Pb in the environment and its transformation into man-made products like batteries that have been distributed throughout the environment resulted in its widespread human and animal intoxication (Abdulsalam, Onajole, Odeyemi, Ogunowo, & Abdussalam, 2015; Liao et al., 2016; Rogers et al., 2014; World Health Organization [WHO], 2014). Battery technicians are at risk of exposure to lead poisoning; supporting their successful adherence to safety practices at the workplaces could protect their health and prevent them from developing occupationally related diseases in the future due to overexposure to lead pollutants (Kalahasthi, Barman, HR, Bagepally, & Beerappa, 2016). The occupational hazards and safety measures have long been a force for behavioral change at the workplace by addressing the hazardous substance that is injurious to workers' health (Kalahasthi et al., 2016; Shark, Sultana, & Asaeed, 2014).

This study was conducted to examine the safety practices on lead poisoning among battery technicians in Lagos, Nigeria. The battery technicians gave the self-reported value of their blood lead levels, and their workplace conditions were assessed with questionnaire. The rate of utilization of personal protective equipment (PPE) was compared among battery technicians who have their workshops in the organized and roadside settings. The associations that exist between safety practices and independent variables were established and measured. The positive social change implication of this study is to improve the safety practices of battery technicians and their workplace condition. The knowledge gained from this study can effectively enable stakeholders and battery technicians to improve their safety practices at the workplaces. The major sections of Chapter 1 include the background of the study, purpose statement, problem statement, and theoretical framework, nature of the study, research questions/hypotheses, and the social implication of the study.

Background of the Study

The battery technicians are among the occupational groups who are exposed to lead hazards because battery cells are made of lead (Abdulsalam et al., 2015; Perry & Amod, 2011; Roger et al., 2014). The first innovative intervention strategy in occupational safety in the19th and 20th century was the advocacy for due diligence on safety practices at the workplaces (Health Canada, 2013; Riva, Lafranconi, D'orso, & Cesana, 2012). The annual work-related diseases caused by exposure to lead are a major significant public health problem throughout the world, particularly in developing countries (Center for Disease Control and Prevention [CDC], 2014; Dongre, Suryakar, Patil, Amekar, & Rathi, 2011; Kalahasthi et al., 2016). The lack of knowledge on safety practices and the symptoms of acute lead poisoning among the battery technicians compound the problem as most cases are not recognized or reported, and the individual does not seek medical treatment (Abdulsalam et al., 2015; Singh, Chadha, & Sharma, 2013).

Although this research regarding safety practices on lead poisoning among battery technicians illuminated important findings, no research was found that has addressed safety practices at the workplaces to guide against the elevation of blood lead level among battery technicians in Nigeria. Instead, researchers have carried out studies that compared the blood lead levels of different automobile technicians and the health impact of long-term exposure to lead (Abdulsalam et al., 2015; Ji et al., 2015; Singh et al., 2013). Given such a gap in the literature, this study was warranted, and I examined the safety practices at the workplaces of battery technicians to guide against the lead poisoning hazard and elevated blood lead levels that present a problem for the practitioners through intervention. This study filled the gap in knowledge as I focused on safety practices, workplace conditions, blood lead levels, and use of personal protective equipment, and compared the safety practices of battery technicians in the organized and roadside settings in Lagos, Nigeria.

Lead Exposure and Associated Disease Burden in Nigeria

The estimated global burden of disease due to lead exposure is 0.6%, and between 0.5 and 1.5 million of these cases areas a result of nonutilization of the safety measures among occupationally exposed workers (CDC, 2014; Huang et al., 2013; Kasperozyk et al., 2013; WHO, 2014). The disease burden categories implicated in lead exposure include systemic effects like gastrointestinal effects, nervous system effects such as intelligent quotient (IQ) defects, encephalopathy, hypertension, diabetes, and cancer (Huang et al., 2013; Jangid et al., 2012; Liao et al., 2016; Zolaly, Hanafi, Shawky, El-Harbi, & Mohamad, 2011). Nine out of 106 disease categories included in the WHO's global burden of disease are being caused by lead poisoning (CDC, 2016; Ji et al., 2015; WHO, 2014). Shaik et al. (2014) stated that battery technicians are exposed to lead fumes through ingestion, inhalation, and transdermal absorption and that they suffer disproportionately from workplace lead exposure during battery manufacturing, smelting, and recycling.

Lead, once absorbed into the body, binds with the erythrocytes and causestoxic effects (Rentschler, Broberg, Lundh, & Skerfving, 2012). Lead may be stored for long a period in mineralized tissues (bone and teeth) and then released again into the bloodstream (Rogers et al., 2014). Bone lead accounts for more than 95% of lead burden in adults and 70% of the burden in children and is a major contributor for workers in lead related occupations (Rogers et al., 2014; Shaik et al., 2014). According to Adedara, Ebokaiwe and Farombi (2013), the population adjusted disease burden due to lead exposure in Nigeria was estimated from the regional analysis for relative risk in the following disease categories: prematurity, nervous system, cancers, dental caries, congenital anomalies, low birth weight, mild mental retardation (intelligent quotient level 50-69), hypertension, genitor-urinary disease, and cerebrovascular disease.

Problem Statement

Lead has become widely dispersed throughout the environment because of the human activities that involve the use of lead products (CDC, 2014; International Labor Organization, [ILO], 2012). The estimated global burden of diseases that occurred due to lead exposure is 0.6%, and between 0.5 and 1.5 million of these cases are due to nonutilization of the safety measures among occupationally exposed workers (CDC, 2014; Huang et al., 2013; Kasperozyk et al., 2013; WHO, 2014). The annual work related diseases caused by exposure to lead poisoning are a major potential public health problem throughout the world, particularly in developing countries (CDC, 2014; Dongre et al., 2011; Singh et al., 2013). The battery technicians’ are among the occupational group’s who are exposed to lead poisoning hazards because battery cells are made of lead (Abdulsalam et al., 2015; Perry & Amod, 2011). The exposure route includes oral ingestion, dermal absorption of lead particles, inhalation of lead fumes when smelting the lead cells, and during washing of the lead cell in water (Abdulsalam et al., 2015; Perry & Amod, 2011).

Researchers have carried out studies that compared the blood lead levels of different automobile technicians and the health impact of long-term exposure to lead, but studies on safety practices at the workplaces to guide against the elevation of blood lead level among battery technicians have received low attention in Nigeria (Abdulsalam et al., 2015; Singh et al., 2013). The lack of research presents a problem for practitioners in addressing the lead poisoning hazards among the battery technicians population through intervention. This study intended to fill the gap in knowledge as it focused safety practices, workplace conditions, and use of personal protective equipment.The study also compared the safety practices of battery technicians in the organized and roadside settings in Lagos, Nigeria, and the likely effect of lead exposure and associated health implications.

Purpose

In this study, I assessed, tested, and described the association that exists between safety practices, workplace condition, blood lead levels, the rate of utilization of personal protective equipment, and I compared the safety practices of battery technicians in the organized and roadside settings in Lagos, Nigeria. Also, I conducted the study to understand the segments of safety practices of the battery technicians that could require special attention at the workplace. Furthermore, I conducted the study to assess the safety behavior of the battery technicians and to impact the behavioral change on lead poisoning safety towards positive action.

The safety practice that was identified as a gap in the literature was addressed with the primary data gathered from battery technicians using questionnaires. I used a quantitative method, primarily a cross-sectional approach to predict the safety practices among the battery technicians. In addition, the information on demographic and occupational characteristics of battery technicians like age, marital status, income, settings of their workshop, education level, years of experience, and knowledge of the importance of safety practices were collected and related to their safety practices at the workplace, and the value of blood lead levels reported by the battery technicians were analyzed.

Research Questions/Hypotheses

The research questions and hypotheses of this study are as follows:

1. RQ1: Is there an association between workplace condition of battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery technician education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience)?

$H_0$1: There is no association between workplace condition of battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery technician education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

H_a1: There is an association between workplace condition of battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery technician education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

2. RQ2: Is there an association between blood lead levels and safety practices of battery technicians controlling for the covariates (availability of safety equipment, battery technician education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience)?

   $H_0$2: There is no association between blood lead levels and safety practices of battery technicians controlling for the covariates (availability of safety equipment, battery technician education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

H_a2: There is an association between blood lead levels and safety practices of battery technicians controlling for the covariates (availability of safety equipment, battery technician education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

3. RQ3: Is there an association between the education level of battery technicians and the safety practices on lead poisoning controlling for the technician's safety practices covariates (marital status, technician's income, and technicians location [either in the organized or roadside setting])?

   H_03: There is no association between theeducation level of battery technicians and the safety practices on lead poisoning controlling for the covariates (marital status, technician's income, and technicians location [either in the organized or roadside setting]).

   H_a3: There is an association between theeducation level of battery technicians and the safety practices on lead poisoning controlling for the covariates (marital status, technician's income, and technicians location [either in the organized or roadside setting]).

4. RQ4: Is there an association between knowledge of safety practices on lead poisoning and utilization of personal protective equipment (PPE) by battery technicians at the workplace controlling for the covariates (age, education level, marital status, years of experience, and location of the workshop [either in the organized or roadside setting])?

$H_0 4$: There is no association between knowledge of safety practices on lead poisoning and utilization of PPE by battery technicians at the workplace controlling for the covariates (age, education level, marital status, years of experience, and location of the workshop [either in the organized or roadside setting]).

$H_a 4$: There is an association between knowledge of safety practices on lead poisoning and utilization of PPE by battery technicians at the workplace controlling for the covariates (age, marital status, years of experience, and location of the workshop [either in the organized or roadside setting]).

5. RQ5: Is there an association between perceived risk of lead poisoning and utilization of PPE by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning)?

   $H_0 5$: There is no association between perceived risk of lead poisoning and utilization of PPE by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning).

   $H_a 5$: There is an association between perceived risk of lead poisoning and utilization of PPE by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technicians income, years of experience, and knowledge of the importance of safety practices on lead poisoning).

Theoretical Foundation

The theoretical model of health behavior and workplace self-protective behavior by Dejoy (1996) was applied to this study. Dejoy model is exemplary because it contains various influencing factors extracted from verified theories and systematizes stages of behavior change. Dejoy developed this integrative health protective behavior model based on the health belief model, the theory of reason action, the theory of planned behavior, and the transtheoretical model. Dejoy's integrative health protective model emphasizes that safety practices at the workplace depend on the following factors: training acquired on safety equipment, self-protective behaviors, rate of utilization of the PPE, provision of safety facilities, and provision of a conducive safe climate at the workplace.

Dejoy (1996) model applies to this study as it deals with the workplace self-protective behavioral change. The model is an integrative health protective behavior that encompasses all aspects of self-protection with regards to human behavior at the workplaces (Kim, Oh, Suh, & Seo, 2014). The interaction of human and other determinant factors influence the self-protective behavior of battery technicians at the workplaces. Dejoy stated that human behavior at the workplaces is moderated with the safety climate, which is the environmental factors (combination of social and organizational factors) and workplace conditions. The work environment with high social support and value-expectancy could influence the protective safety behavior (behavioral factors) of the battery technicians. In this situation, the protective behavior could be effectively adhered to, but if the value-expectancy of the workplace is low, there is a tendency for the low level of adherence or lack of adherence to safety practices.

Furthermore, the facilitating condition (psychosocial factors) emphasizes the importance of mental well-being, social supports, and perception of battery technicians about the control of lead exposure through adherence to safety practices. The interactive nature of factors of behavioral intervention could influence battery technicians, thus motivating them to follow safe practices in the workplace environment (a) by realizing the support of the environment, and viewing it as an important source of reinforcement for behavioral change, and sustenance and (b) that the achievement of behavioral goals is through directing attention to skills through training and utilization of resources available at their disposal in the workplace (Kim et al., 2014).

The important application of this model is that it focuses on the interaction of an individual with environmental condition, combined with behavioral and psychosocial factors, and the expectation that influences the reaction to various hazardous threats at the workplace. The model diagnosed the behavioral factors needed to drive the development of preventive strategies, that is factors that could facilitate or hinder protective behavior, and this often depends on the antecedents that allow motivation or aspiration to be realized. The provision of safe working conditions and thecharacteristics of the individual, like his or her beliefs, attitudes, and values placed on life could determine the predisposing concepts that provide motivation for self-protective behavior (Kim et al., 2014). Furthermore, the model has been used extensively to plan, execute, and evaluate safety practices at the workplace, in health education, and in related programs in different settings. I designed figure 1, to represent Dejoy workplace self-protective framework which I applied to the battery technicians studied.

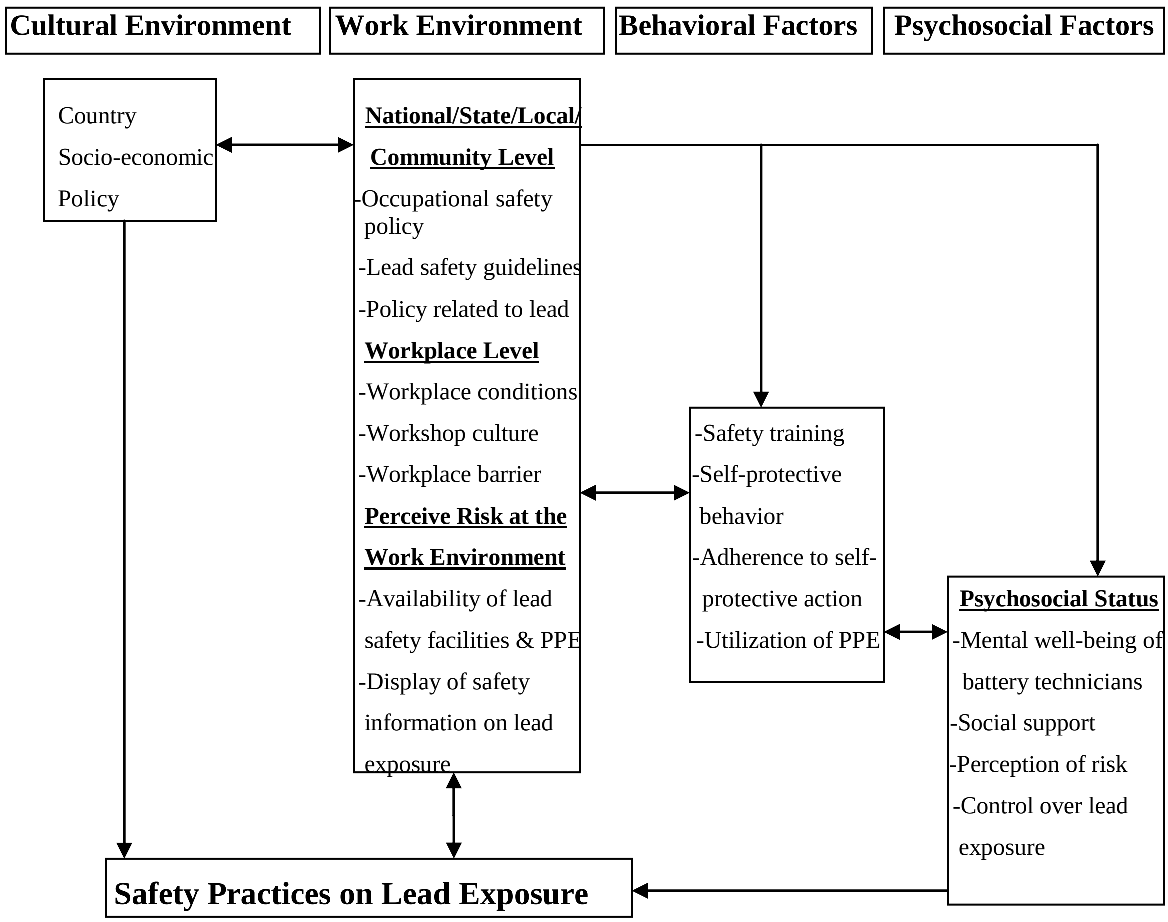


Figure1. Diagrammatic representation of the theoretical framework applied to safety practices on lead exposure for battery technicians, March 2016.

Nature of the Study

The nature of this study was a quantitative, cross-sectional design; I tested the stated hypotheses using the variables of interest and answered the research questions. The cross-sectional design naturally observes, measures, and records the attribute of variables in the study (Creswell, 2009). The cross-sectional survey design is useful for gathering data from dispersed geographical districts in a short time with minimal cost, and the study findings could be generalized to the entire population (Creswell, 2009). In this study, a survey was conducted to collect data on safety practices on lead poisoning at the workplace of the battery technicians.

The key studied variables included outcome variables (dependent variables), which were used to measure the battery technician's safety practices (SAFETY), and this was the primary or main outcome variable, and the use of PPE was the secondary outcome variable. The independent variables (predictor variables) included the workplace conditions, blood lead levels, education attainment, the location of battery technicians, and knowledge of safety practices. The covariate variables in this study were age, marital status, and years of experience on the job. All these variables were the variable of interest in this study on safety practices on lead poisoning.

The setting of this study was Lagos, a megacity located in the south western region of Nigeria with the largest and most extensive road networks in West Africa. Rudestam and Newton (2015) defined sample as a subset of the population being studied. The target population sampled for this study was adult battery technicians, aged 18 years and above. In this study, the sampling strategy used was a multistage sampling method and systematic sampling technique. The population of the two selected local government council areas (Agege and Ikeja local government councils) in Lagos was delimited into a geographical area, districts, and wards (individual level). The systematic sampling technique was used to select the sample frame (participants) who eventually participated in this study using an interval that corresponded to the proportion of the population under study.

I used a quantitative method, cross-sectional design to describe and established an association that exists between the independent and dependent variables of this study. The quantitative method, cross-sectional design, focused on the understanding of how battery technicians approached facilitating conditions, and safety practices at the workplace, which wasthe primary objective of this dissertation. Focusing on battery technicians' safety practices at the workplace is consistent with Dejoy's model (1996) that defined facilitating condition, and safety practices at the workplace as an expanded concept of the barrier, and a combination of social supports in the workplace.

To elucidate how a safe workplace could be achieved, the objective rating of the battery technicians' safety practices at the workplaces was examined across time. The quantitative analysis was used to establish the measurable relationship between the use of safety practices and workplace condition, utilization of PPE, and knowledge of safety practices, and differences in safety practices of battery technicians in the organized and roadside settings. In this study, I collected primary data with self-administered questionnaires, and the data were analyzed electronically with SPSS software version 21.

Operational Definition of Terms

Battery technician's age: The calculated time in years that the battery technicians have lived on earth since birth.

Battery technician's educational level: The level of formal education the battery technician has attained.

Battery technician's perceived risk: The perception of battery technicians on the dangers that are associated with exposure to lead poisoning at the workplace.

Battery technician's safety practice knowledge: Battery technicians' understanding of workplace hazards and the ability to respond concisely to questions related to safety against lead poisoning.

Battery technician's years of experience: The chronological time in years that a battery technician has spent practicing the profession.

Blood lead levels (BLLs) of battery technicians: The biomarker used to determine the blood lead level of toxicity, exposure and risk of lead poisoning. Less than 5.0µg/dL (0 – 4.9µg/dL) is not considered lead poisoning, but 5µg/dL and above is considered elevated blood lead level (National Institute of Occupational Safety and Health [NIOSH], 2015).

Personal protective equipment at the workplace (PPE): These are personal safety tools that protect battery technicians in the workplaces against lead exposure. These include face mask, eye goggles, protective clothing, and safety helmets.

Safety practices: The procedures adopted by battery technicians for carrying out specific tasks that ensure the workers' exposure to lead at the workplace is controlled in a safe manner.

Self-protective behavior: The behavior which enables battery technicians to recognize lead exposure situations in which their personal space and sense of safety may be compromised. Self-protective behavior is evident in the use of lead safety equipment that could guide against lead poisoning, stoppage of cigarette smoking at the place of work, and visiting health clinic for medical check-up to reduce risks to health.

Workplace conditions: The availability of safety items that are used to protect battery technicians against lead exposure within the workplace environment. These include hand soap, single use towel, drinking water, cups, water to wash hand at workplace, bathroom to shower after work, training on safety practices, washing water separated from drinking water, information about lead poisoning safety measures display, and the boss talking of safety measures and practices at the workplace.

Assumptions

Assumptions identify external influences that are risks to the successful implementation of the study (Rudestam& Newton, 2015). The following assumptions were made for this study: The cross-sectional design is an appropriate approach to survey adult battery technicians' aged 18 years and above in Lagos state Nigeria, considering the dispersed nature of the subjects. The safety practice on lead poisoning at the workplaces of battery technicians is a strategy to enhance the quality of life by maintaining health status, and protecting the technicians from developing occupationally acquired diseases.

It is assumed that all the battery technicians could be able to understand, comprehend, and fill the questionnaire that was administered.

Furthermore, I assumed that the multistage sampling and systematic random sampling technique used in this study design to estimate the proportion of battery technicians was accurate and correct. I also assumed that the research method was appropriate for the nature of population surveyed. Moreover, I assumed that the economic and political situation of Nigeria remained stable, and that the battery technicians work in their real workplace as usual. In this study, the reasons why the assumptions were necessary is to simplify a complex analysis of safety practices into more manageable parts by establishing an ideal benchmark, and control conditions (control variables) that are subsequently changed to evaluate an analysis, and identify particular cause-and-effect relations.

Scope and Delimitations

In this study, the dependent variable was safety practices (SAFETY) and it was the primary or main outcome variable. The use of personal protective equipment (PPE) was the secondary outcome variable. For the safety practices status of battery technicians to be measured, the independent variables (predictor variables) of interest were the workplace conditions, knowledge of the importance of safety practices, education level, blood lead levels, and perceived risk of lead poisoning by the battery technicians. In this research, I used quantitative, and a cross-sectional approach to survey the participants. The study setting was Lagos, and the two selected local government council areas (Agege and Ikeja) were delimited into the geographical area, district, and individual level.

The study inclusion variables were workplace conditions, utilization of personal protective equipment, safety practices, blood lead levels, perceived risk, and knowledge of the importance of safety practices among battery charging technicians. The study was delimited to adult battery technicians' aged 18 years and above, with their workshops located in the organized or roadside settings in Lagos, Nigeria. In this study, the sampling strategy used was appropriate for the study setting, and it ensured a true representation of the target population. The study was generalized to the entire battery technician's population in Lagos, Nigeria. The reliability and external validity related to the study was emphasized.

Limitations

This study contains a few limitations. First, the level of safety practices on lead poisoning at the workplace of the participants could be underestimated as the study population did not cover all the registered battery technicians in Lagos state, Nigeria. If there is no time limit and the study includes all the registered battery technicians, more battery technicians who are exposed to lead poisoning and exhibit nonadherence to safety practices could be identified. The second limitation is that this study was a cross-sectional design; only battery technicians who met the study inclusion criteria, and fell into sample frame in their workshop duringthe survey were allowed to participate in the study.

Thirdly, I designed the the instrument, and it was assessed by the dissertation supervisory committee members and two other experts in occupational medicine and safety, and pilot study was conducted for validity and reliability. If judgment on the face and content validity of the questionnaire was not accurate, this could be a limitation of this study. Fourthly, the sequence between predictor variables (independent variables) and outcome variable (dependent variable) cannot be established with the cross-sectional approach, and this could be a limitation. Finally, the fifth limitation could be information recall bias as I used a self-reported method to assess the safety practice history of battery technicians. All these factors above could limit the generalizability of the findings of this study to the entire population of battery technicians in Nigeria.

The reasonable measure that I used to address the limitations was that a plan was put in place to ensure the consistency of the study results by controlling for covariates like age, years of experience, education level, and methodology in the analysis stage. Secondly, the internal and external validity of the instrument was established by conducting a validation test (test -retest) using 50 adult battery technicians in Ibadan City, Nigeria, which is about 150 kilometers away from Lagos. This method was used to assess the empirical, face, construct, and content validity of the instrument before putting it to use in the study. Furthermore, the internal consistency of the study instrument, that is how well the questions synchronized together, was established by analyzing the items in the questionnaire with Cronbach's Alpha. The value obtained from Cronbach's alpha analysis was 0.8 and is high, therefore, indicating strong internal consistency. However, if the value is low, it means weak internal consistency of the items.

Significance of the Study

The importance of this study is that it fills a gap in knowledge as I focused on the detailed safety practices at the workplace of battery technicians. In the study, I also established the significant difference that exists in the safety practices of battery technicians in the organized setting compared with those in aroadside setting. I found an association that exist between safety practices and workplace condition, blood lead levels, utilization of PPE, and knowledge of safety practices. Finally, the significance of this study was to improve compliance with safety practices, to reduce morbidity, disability, and mortality associated with lead poisoning hazards among reasonable numbers of battery technicians in the organized and roadside settings in Nigeria.

Furthermore, I elicited how battery technicians were not protecting themselves from exposure to a lead poisoning hazard; thus, there is an urgent need for them to imbibe positive behavioral change towards protection against exposure to lead toxins at the workplaces. Kalahasthi et al. (2016) stated that occupational hazards and safety practices have long been a force for behavioral change at the workplace by addressing the hazardous substance that is injurious to a worker’s health. Since battery technicians were at risk of exposure to lead poisoning, supporting their successful compliance with safety practices at the workplaces could protect their health and prevent them from developing terminal diseases in the future as a result of exposure to lead poisoning at their workplaces (Kalahasthi et al., 2016).

Significance to Theory

The important application of Dejoy (1996) model to this study is that it focuses on the interaction of an individual with environmental factors, behavioral factors, and psychosocial factors that influence reactions to various health threats in the workplace. The model diagnosed the behavioral factors needed to drive the development of preventive strategies that could facilitate or hinder safety practices. The value placed on life could determine the predisposing concepts that could provide motivation for safety practices. Human behavior inthe workplace is moderated with the safety climate, which is environmental factors (combination of social and organizational factors), and it is a workplace condition.

Furthermore, the facilitating condition (psychosocial factors) emphasizes the importance of mental well-being, social supports, and the perception of battery technicians about the control of lead exposure through the adherence to safety practices. The interactive nature of factors of behavioral intervention could influence the battery technicians' beliefs, attitudes, and values placed on life, thus motivating them to follow safe practices in theirwork environment (a) by realizing the support of the environment and viewing it as an important source of reinforcement for behavioral change and sustenance, and (b) that the achievement of behavioral goals is through directing attention to skills and resources available at their disposal in the workplace (Kim et al., 2014).

Significance to Practices

The importance of this study to practice is that it could be of benefit to battery technicians in reducing the rate of morbidity, mortality,and disability, which were due to occupational diseases (WHO, 2014). Unfortunately, Nigeria remains one of the developing countries in which occupational safety and the health act enforcement rate is less than 10%, with low or a lack of a monitoring program for blood lead level among the occupationally lead exposed workers. Without monitoring, supervision, and enforcement of safety practices measures at the workplaces, Nigerians workers that were exposed to lead hazard could continue to accumulate lead toxins in their blood. To improve the standard of safety practices in the workplace and to safeguard the health of the battery technicians, I conducted this study to fill the gap in the knowledge on safety practices.

Significance to Social Changes

The positive social change of this study was that it could improve the knowledge of battery technicians on the factors that could influence safety practices in the workplace environment. The study could also impact the self-protective behavior of battery technicians by changing their perspective of behavioral safety practices towards positive actions through improvement in and embracing the culture of regular use of personal protective equipment, and the washing of hands and the face with soap and water at the workplace. This positive social change could prevent them from accumulating lead in their blood, consequently protecting their health.

The knowledge of lead exposure safety practices that could be gained by battery technicians' who participated in this study could enable them to articulate factors to be focused on to improve their safety practices. The battery technicians who took part in this study may now understand the segments of safety practices that required special attention towards improving their safety at the workplace. Finally, the findings of this study could cause an improvement in working conditions and safety practices and increase the rate of utilization of PPE at the workplace of battery technicians, which consequently could reduce the burden of occupationally lead-related morbidity, disability, and mortality (Haider & Qureshi, 2013).

Summary and Transition

In occupational safety, the most cost-effective health intervention is to guide against the hazards in the workplaces, through maintaining and sustaining standard safety practices. Regular utilization of PPE in the workplace could protect workers against occupational lead hazards that are injurious to health and prevent them from developing occupationally related diseases. In Nigeria, the performance of occupational safety and health programs has consistently been below the international standard since the enactment of the occupational safety act of the Federal Republic of Nigeria in 1983 with the enforcement rate still below 10% onaverage. Consequently, Nigeria could be one of the countries in the world with a record of the worst mortality rates of occupational lead poisoning due to the lack of knowledge and the battery technicians were among the occupational groups directly exposed to lead poisoning. To worsen the situation, presently there is no monitoring and surveillance of workers who are occupationally exposed to lead poisoning in Nigeria.

This study addresses the safety practice that was identified as a gap in the literature, and I used a quantitative method, cross-sectional design survey. I tested and described the association that exists between safety practices and workplace condition, blood lead levels, and utilization of PPE, and I compared the safety practices of battery technicians in the organized and roadside settings in Lagos, Nigeria. I predicted the safety practices among the battery technicians by asking them to complete the questionnaire that was used to measure their workplace conditions, safety practices status, and rates of utilization of PPE.

Knowledge gained from this study could cause positive change in the behavior of battery technicians by improving the rate of utilization of personal protective equipment at the workplace. Consequently, there could be a reduction in morbidity, mortality, and disability that are associated with lead poisoning occupational hazards at the workplace. In Chapter 2, I continue with reviewof the existing literature on lead poisoning, safety practices in the workplace, and also the theoretical basis of the study. Furthermore, in Chapter 3, I presented the research design and method that was used to answer the research questions, while in Chapter 4, I reported the study findings. Finally, the discussion, implications, limitations, conclusion, and recommendations of the study are presented in Chapter 5.

Chapter 2: Literature Review

Introduction

The literature review of this quantitative study is organized historically, conceptually, and methodologically. The rationale for this study is that it was motivated by a practical concern about the safety practices at the workplace, and its importance towards the reduction of lead poisoning among battery technicians. The contribution of this investigation was to address the concern about safety practices by improving the knowledge of the battery technicians, and to encourage them to keep to the standard safety practices at the workplace to avoid lead intoxication that could cause long-term health problems (Getaneh, Mekonen, & Ambelu, 2014; Liao et al., 2016).

Reutschler et al. (2012) argued that the intoxicated and cumulative features of Pb in every individual have been found to generate adverse health effects, particularly among lead acid battery (LAB) workers who are most susceptible to its long-term exposure. The annual work-related diseases caused by exposure to lead poisoning are a major potential public health problem throughout the world, but this continues to be a significant public health issue in developing countries like Nigeria (Abdulsalam et al., 2015; CDC, 2014; Singh et al., 2013).

Over the years, researchers have determined, examined, and compared the blood lead levels of automobile technicians in Nigeria, but the literature on lead poisoning safety practices and utilization of personal protective equipment at the workplace is scarce. A gap still exists in the literature on the factors affecting safety practices at the workplace of battery technicians. In this study, a comparison and an assessment of the safety practices at the workplace of battery technicians was carried out to determine whether an association exists between safety practices, and workplace condition, blood lead levels, knowledge of the importance of safety practices, and rate of utilization of the PPE among battery technicians. This literature review was organized to follow the stated hypotheses and study methodology.

Literature Search Strategy

A researcher aiming to conduct a quality research study needs to put in place a strategic plan for managing the resource for literature review (Rudestam & Newton, 2015). The strategy employed by me to gather resources for this literature review was the use of the following keywords to search: *historical perspective of occupational lead poisoning, biological mechanism of lead poisoning, blood lead levels defined, reference blood lead level for occupationally exposed workers, incidence of lead poisoning in Nigeria, lead exposure pathways for battery charging technicians, preventive strategy for lead poisoning among battery technicians, policy response on lead poisoning, battery technicians workplace conditions, safety practices at the workplace of battery technicians, self-protective behavior and use of PPE, knowledge of the importance of safety practices, and health impacts of lead intoxication.*

The tools that were used to find relevant resources were categorized as follow: catalogs, Google scholar, bibliographical databases, internet subject gateways, internet search engines, open access databases, and book chapters related to the topic. Other public health databases searched online for resources included Science Direct, Springer Link, PubMed, MedLine, Willey database, Research Gate, Cochrane Library, Science

Index, OSHA, ProQuest, CINAHL PLUS, JAMA, WHO, United States CDC, Nigeria government database, SAGE journal, Achive of Basic and Applied Medicine, Industrial Journal of Clinical Biochemistry, American Journal of Industrial Medicine, International Archive of Occupational Environmental Health, Elixir Pollution Journal, Safety & Health Assessment & Research for Prevention, American Journal of Public Health, Safety and Health at Work (SH@W), BioMed Research International, and Environmental Health Journal.

The materials that were relevant to the lead poisoning, blood lead levels, and safety practices at the workplace were identified, arranged, and stored. This was an important stage before I commenced writing, and all the resources relevant to the literature were made available in hard copies for easy analysis. The resources were organized in a way that assisted me inthe writing process. The articles were read and grouped according to relevance, and the literature review was based on each article read. Since there is a possibility that a computer hard drive containing hundreds of thousands of files could fail, the articles used for this literature review were kept in hard copies. The research materials used for this study were mostly from year 2011 to 2016, except for the materials used in the theoretical framework session that were from year 1996 and 2014.

Theoretical Foundation

This study was conducted in Lagos, Nigeria, and I carried out data collection for 6 weeks among the battery technicians. The survey was a quantitative, cross-sectional design, and it addressed the research questions, and the hypotheses using the stated variables of interest. The study design systematically established an association that exists between the dependent and independent variables. The quantitative, cross-sectional approach described and document the situation as it occurred (Creswell, 2009). In this study, I collected primary data with the administration of questionnaires that have structured close-ended questions.

A clear, unambiguous questionnaire was used to collect information from the battery technicians about their workplace conditions, safety practices, rate of utilization of PPE, and blood lead levels. The safety practices status of battery technicians was measured with the responses to questions in the safety practices section of the questionnaire, and the blood lead levels of the battery technicians'were based on the self-reporting value documented by them in the questionnaire. The methodological rigor was relatively easy, so a good response rate was achieved and representative data were obtained.

The quantitative method, cross-sectional design was used to assess the safety practices of battery technicians at the workplace. The multistage sampling method with a systematic sampling technique was used to select the participants to achieve a true representation of the target population that was geographically dispersed. Required time, effort, and skill were put in place to construct a valid measure of safety practices of battery technicians in their workplaces. Furthermore, the safety practice status of battery technicians in the organized and roadside settings was compared.

According to Akintola (2015), the theoretical framework is a bridge between the theoretical and practical aspect of a research; this study theoretical framework was used to link the practical components of the investigation of safety practices on lead poisoning among the battery technicians under study with the theoretical aspects of the study, and is sometimes referred to as paradigms. Akintola (2015) stated that the starting point in developing a research is to identify the method, methodology, and epistemology that could be used in the research processes, and to justify the choice. The research design (quantitative method, cross-sectional approach) selected for this dissertation was appropriate because I emphasized a quantitative research problem as the study described, explained, and predicted the safety practices of the population studied. Moreover, the research questions and the method chosen showed an alignment, and this is a good justification for selecting the design.

The research questions of this study specified dependent and independent variables, and the questions related variables just as in the purpose statement. Furthermore, the design was preferred due to the large population of the study setting, and the dispersed nature of the subunits studied. In addition, the findings from this design could be generalized easily to the entire population of battery technicians. Finally, this design is reliable as it determined an association by statistical calculation and computing of effect size in comparison with a *p*-value of 0.05 at a 95% confidence interval. The theoretical framework of this study usedthe epistemology, theoretical perspective/focus, methodologies, and methods summarized in Table 1.

Table 1

Schematic Outline of the Theoretical Framework for Safety Practices on Lead Poisoning for Battery Technicians Lagos, Nigeria, January 2016

Epistemology	Theoretical focus	Study methodology	Methods
-Constructions	-Interpretive	-Survey research	-Questionnaire
	-Symbolic interactions'	-Quantitative study	-Review of workplace conditions
	-Theory application in part or as a whole	-Cross-sectional	-Review of safety practices and utilization of PPE
		-Deductive approach	-Review of blood lead levels,knowledge, and perceived risk of lead poisoning at the workplace -Primary data collection and statistical analysis - Reduction of data
			- Discussion
			-Recommendation and references

Theoretical Model

The theoretical model of health behavior and workplace self-protective behavior by Dejoy (1996) was applied to this study. Dejoy’sexemplary model contains various influencing factors extracted from verified theories and systematizes stages of behavioral change. Dejoy developed this integrative health protective behavior model based on the health belief model, the theory of reason action, the theory of planned behavior, and the transtheoretical model. Dejoy integrative health protective model emphasizes that safety practices at the workplace depend on the following factors: training acquired on safety equipment, self-protective behaviors, the rate of utilization of the PPE, provision of safety facilities, and provision of a safe environment at the workplace.

Dejoy (1996) model applies to this study as it deals with safety and self-protective behavioral practices at the workplace. The model is an integrative health protective behavior that encompasses all aspects of self-protection with regards to human behavior at the workplace (Kim et al., 2014). The interaction of human and other determinant factors could influence the self-protective behavior of battery technicians at the workplaces. Dejoy stated that human behavior at the workplaces is moderated with the safety climate, which is environmental factors (combination of social and organizational factors) and workplace conditions. The work condition with high social support and value-expectancy could influence the protective safety behavior (behavioral factors) of the battery technicians (Dejoy, 1996). In this situation, the protective behavior could be effectively adhered to, but if the value-expectancy of the workplace is low, there is a tendency for a low level of adherence or lack of adherence to safety practices.

Furthermore, the facilitating condition (psychosocial factors) emphasizes the importance of mental well-being, social supports, and perception of battery technicians about the control of lead exposure through the adherence to safety practices. The interactive nature of factors of behavioral intervention could influence battery technicians, thus motivating them to follow safe practices in the workplace environment (a) by realizing the support of the environment and viewing it as an important source of reinforcement for behavioral change and sustenance, and (b) that the achievement of behavioral goals is through directing attention to skills through training and utilization of resources available at their disposal in workplace(Kim et al., 2014).

Relevance of Dejoy's Model to This Study

The significant application of this model is that it focuses on the interaction of an individual with environmental conditions combined with behavioral and psychosocial factors and expectations that influence the reaction to various hazardous threats at the workplace. The model diagnosed the behavioral factors needed to drive the development of preventive strategies, that is factors that facilitate or hinder protective behavior, and this often depends on the antecedents that allow motivation or aspiration to be realized. The provision of safe working conditions and characteristics of the individual like beliefs, attitudes, and the values placed on life determine the predisposing concepts that provide motivation for self-protective behavior (Kim et al., 2014). Furthermore, the model has been used extensively to plan, execute, and evaluate the safety practices in the workplace, health education, and related programs in different settings.

Literature Review

Historical Perspective of Occupational Lead Poisoning

Preindustrial era and occupational lead poisoning: occupational lead poisoning is one of the most known occupational disease that has been identified since the earliest times (Kuijp, Huang, & Cherry, 2013; Riva et al., 2012). According to Riva et al. (2012), the acute effects of lead poisoning have been recognized in manual workers and slaves but were barely considered by medicine at the preindustrial era in the 16th century. The first clear description of lead toxicity was dated back to the second century BC when a physician named Nicander identified the acute effects (colic pain) associated with high-dose exposure to lead (Riva et al., 2012). The extensive uses of lead products have led to its toxic effects in the exposed population (Bockelmann, Pfister, & Darius, 2011).

Haider and Qureshi (2013) stated that those suffering from lead poisoning disease were majorly poor artisans of a low social class, and in general, this occupational group was not protected. Riva et al. (2012) stated that the first medical hypotheses on lead poisoning were formulated during the period of renaissance. In the fifth century, a German physician Ellenberg (1440-1499) emphasized the benefit of preventive measures to avoid lead poisoning, and subsequent deaths arising from overexposure to lead pollutants (Huang et al., 2013). He advised the artisans working with lead metals “to cover their mouth and nose with a rag” and that they should keep an open environment to reduce the absorption of lead fumes while in the workplace (Huang et al., 2013). Bauer (1494-1556) identified the health problems among German miners.

Another physician, Paracelsus (1493-1541), developed a theory and stated that "only the dose permits something not to be poisonous" (Rival et al., 2012). This Paracelsus theory represented the basis for the development of toxicology that was bitterly and widely criticized by the scientific world at that time (Rival et al., 2012). Two centuries later, Stockhausen, a physician in Germany, reopened the Paracelsus medical model, attributing the etiology of a miner's asthma to the lead fumes from lead compounds (Rival et al., 2012). A decades following reopening of medical model on lead poisoning, Ramazzin (1633-1714) published numerous articles in England about the risk of the manufacturers of white lead paint and glass.

Ramazzin identified that all the lead paint processing techniques used were dangerous (Rival et al., 2012). Ramazzin stated that workers who worked with lead suffered from palsied hands, fatigue, abdominal colic, cachexia, loss of teeth, and a cadaverous-looking face (Rival et al., 2012). According to Ji et al. (2015), the overexposure to lead poisoning was experienced in the 17^{th}century in the French and English countryside, which caused an intense painful and debilitating disease (ColicaPictonium) that frequently ended in death. This was first identified by Citois (1572-1652) in1639 but no action was taken at the government or individual level at that time (Ji et al., 2015).

Industrial revolution and occupational lead poisoning: the saturine colic epidemic that occurred during the 17th century was diagnosed by Baker (1722-1809) in 1767, which was 70 years after the first acknowledgment by Gockelas that lead poisoning is dangerous (Jangid et al., 2012). At the beginning of 19^{th} century scientists have clearly understood the mechanism of lead poisoning by dietary intake (Khan et al., 2011). Frank (1745-1827) a German hygienist suggested that people should avoid drinking water that flows in pipes made of lead due to the report of saturnine colic observed by him and another physician (Rival et al., 2012). During the industrial revolution in which there is an intensive use of lead metal in manufacturing systems, and with lack or improper preventive measures resulted to increased number of workers affected by the chronic lead poisoning (Kuijp et al., 2013).

Tanquere indicates the neuro-psychomotor manifestation of lead poisoning; he coined the medical term encephalopathy for the first time (Bockelmann et al., 2011). The neurological complication of lead exposure was confirmed by Esquirol (1772-1840) in 1838 and Tuke (1827-1895) in1880 (Bockelmann et al., 2011). Both of them provided cases of mental disorder from chronic ingestion of lead pollutants, and the related neuropathy, hypertension, and effect on pregnancy outcome were identified, and described in the medical literature (Bockelmann et al., 2011). Following these publications, the politicalworld, scientist communities, and the medical professionals could no longer ignore the lead poisoning problem (Rival et al., 2012).

The work of Thackrah (1775-1833) on how to improve the worker's health condition in England contributed to the development of English legislation and formulation of principle guiding the removing and replacing of harmful agents in the production cycle for workers (Rival et al., 2012). According to Rival et al. (2012), in the following decades, children in the United Kingdom were forbidden to work in white lead factories (1878). The Parliament of UK later openly took an action by approving the factories (prevention of lead poisoning) Act in 1883, and this may be considered as the first worldwide legislative initiative to lessen the burden of a specific occupational hazardous condition "Lead Poisoning" (Rival et al., 2012).

Twentieth century development and occupational lead poisoning: in the 19thcentury and despite the industrial development, the health of workers in most western countries still took little account of lead poisoning (ILO, 2012). The institution of UK labor inspectorate significantly contributed to reducing number of cases of lead poisoning (ILO, 2012). In 1904, series of studies were carried out in the US, the studies pursued intuition on children lead poisoning, and it was indicated that children who play with lead coated paint toys or even built with the metal itself were equally exposed to lead poisoning (CDC, 2012). A pioneer researcher on lead poisoning in the US, Hamilton (1869-1970) pressured the United States government to take an urgent measure on the issue (Rival et al., 2012).

Rival et al. (2012) stated that the first preventive strategies in the factories was introduced in the mid 20th century, with the introduction, and use of exhaust ventilation, personal preventive equipment, wetting dusty process and the chelating agent, and the entire above measures provided therapeutic tool against lead poisoning. In the year 2000, the US government developed comprehensive sets of lead poisoning prevention law, and these have significantly reduced the environmental lead exposure with the economic benefit of 213 billion US Dollar per year (CDC, 2012). The board of director at the American college of occupational health and safety professional were also charged with environmental management in the early 1990 (CDC, 2012). For this reason, a new disciplined "Occupational and Environmental Health" emerged with the mandate of detecting harmful agents (such as lead poisoning which is the paradigm of this study) in both living and working environment (CDC, 2012).

Blood Lead Levels Defined

The blood lead levels are the most widely used biomarker for the assessment of toxic exposure and risk of lead poisoning (CDC, 2014; Dongre et al., 2011; Jangid, 2012; Kuijp et al., 2013; Reutschler et al., 2012). The venous blood is the most reliable specimen for determination of blood lead level because it is uncontaminated, preferred and considered confirmed (American Academy of Pediatrics [AAP], 2013; CDC, 2014; Sirivarasai et al., 2013). The American Academy of Pediatrics (2013) core clinical service guidelines for the blood lead levels (BLLs) assessment suggested the reference values as follows; less than 5.0µg/dL (0.0 – 4.9µg/dL) is not considered lead poisoning, 5.0 – 14.9µg/dL is considered elevated blood lead level (EBLL), 15.0 – 29.9µg/dL is considered a confirmed elevated blood lead level, 30.0– 69.9µg/dL is also considered a confirmed elevated blood lead level but any value that is 70.0µg/dL and above is a confirmed elevated blood lead level which indicates lead toxicity and requires medical emergency.

According to Kuijp et al. (2013), many studies on blood lead level had indicated that there is “no safe” threshold for exposure to lead and that no amount is too small to induce adverse biological reaction. The definition of limits for “safe” exposure became cloudy, the literature and international conferences on lead caused further confusion as researchers could not agree on a reference value for lead poisoning (Kuijp et al., 2013; Rogers et al., 2014). A 50.0μg/dL for one researcher could be the same as 90.0μg/dL for another researcher (CDC, 2014). Gradually, there was an improvement with effective coordination in developed countries, but developing countries like Nigeria still lag behind due to poor or no control of nonoccupational and occupational lead intoxication (Udiba et al., 2013).

Based on research findings on reference value, the US Center for Disease Control and Prevention in May 2012 gave a reference value of 25.0μg/dL for adult and 5.0μg/dL for children but this value is still high compared to the American Academy of Pediatrics (2013) reference value of 5.0–14.9μg/dL which was considered elevated blood lead level (EBLL). The occupational guideline and regulation worldwide advocated for higher value by argued for 40.0ug/dl as the highest blood lead level to be permitted but 25.0ug/dL and below should be a preferred level for the occupationally exposed adult (Occupational Safety and Health Administration [OSHA], 2015).

Clinical lead intoxication, as well as other clinical occupational morbidity, is still common in developing countries, and several former socialist countries but the situation had improved in developed countries through safe working conditions and notification of cases which are often much milder (CDC, 2016; NIOSH, 2015). Unfortunately, the improved situation in the developed countries is as a result of the relocation of the battery lead smelting, recycling, manufacturing, and storage to developing countries (Kuijp et al., 2013). This regrettable situation did not concern occupational lead poisoning alone but other sources of metal contaminants in the environment (Margaret, 2013; Udiba et al., 2013).

Reference Blood Lead Level for Occupationally Exposed Workers

The occupational groups that frequently have high exposures to lead pollutants include battery manufacturing workers, battery recycling workers, lead smelter workers, lead chemical workers, foundry workers, pigment workers, refinery workers, leaded glass workers, radiator repairer workers, and construction workers (Alberta Occupational Health and Safety [AOHS], 2013; Liao et al., 2016). The National Institute for Occupational Safety and Health (NIOSH, 2015) conducted a survey and measured the blood lead levels of adult in the United States. The results of the survey were used to establish the trend of lead intoxication and for the intervention to prevent lead overexposure.

The US Department of Health and Human Services, US Center for Disease Control and Prevention, and NIOSH (2015) had previously from the year 2009 till November 2015 defined the case definition for the elevated blood lead level (BLL) as a BLL $\geq$ 10.0µg/dL for an adult in the United State. The Occupation Safety and Health Administration of the United States (2015) based its own case definition for elevated blood lead level at BLL $\geq$ 50.0µg/dL (for the construction industry), BLL $\geq$ 60.0µg/dL (for general industry) and allowed workers to return to work when BLL is below < 40.0µg/dL.

The data from the National Health and Nutrition Examination Survey in 2011 showed that the average blood lead levels (geometric mean) of all adults'surveyed in the United States between year 2009 and 2010 was 1.2µg/dL (CDC, 2014). In the year 2015, NIOSH designated BLL < 5.0µg/dL (less than five micrograms per deciliter) of whole blood, in the venous blood sample, as the reference blood lead level for the adult. Conclusively, in December 2015, the National Institute for Occupational Safety and Health, Department of Health and Human Services, and Center for Disease Control and Prevention in United States agreed and defined the case definition of elevated blood lead level for an adult in U.S as BLL ≥ 5.0µg/dL (NIOSH, 2015). A figure was used to illustrate the acceptable value for blood lead level and this can be accessed using the link https://www.cdc.gov/niosh/topics/ables/pdfs/Reference%20Blood%20Levels%20for%20Adults-2015-12-18_508.pdf

Table 2

Blood Lead Level of Occupationally Exposed Adults and Required Safety Actions, March 2016

Blood lead level value in (µg/dL)	Safety decision	Health and safety action
Case definition range		
Blood lead level (0.1µg/dL - 0.49µg/dL)	Case definition for blood lead level but **“no safe value”**	The blood lead level to be checked monthly for 3 months to ensure 0.00µg/dLis achieved.
Blood lead level (0.5µg/dL – 1.49µg/dL)	-Removal from lead exposure if pregnant or may become pregnant. -Evaluation of workplace lead exposure, controls available and work safety practices.	The blood lead level to be checked monthly for 3 months then every 3 months until value of0.00µg/dL - 0.01µg/dL is achieved.
Range that call for caution		
Blood lead level (1.5µg/dL – 1.99µg/dL)	-Reduce exposure and implement changes at workplace. -Worker must be informed of the blood lead level and implication on health. -Evaluation of the sources of the excessive exposure, controls measures available and identification of ineffective work safety practices.	The blood lead level should be checked monthly until value of 0.00µg/dL- 0.01µg/dL is achieved
Range dangerous to health		
Blood lead level (2.0µg/dL – 2.49µg/dL)	Worker must be informed of the blood lead level and implication on health. -Worker must be removed from workplace that contains lead pollutants and medical treatment applied until his or her BLL returns to acceptable level. -The safety action to reduce exposure to lead must be significantly reduced by administrative controls/engineering controls/ensuring safe work practices.	The blood lead level should be checked monthly until value of 0.00µg/dL- 0.01µg/dL is achieved
Range that signify lead toxicity		
Blood lead level ≥ 5.0µg/dL	Worker must be informed of their current blood lead level. -Worker must be removed from workplace that contains lead, medical treatment applied until BLL returns to acceptable level with regular medical assessment. -Notify Director of medical services. -Identify sources of lead exposure and implement corrective actions to eliminate or reduce exposure potential. -Effectiveness of worksite control must be evaluated and control measures must be implemented to reduced exposure.	The blood lead level should be checked monthly until value of 0.00µg/dL- 0.01µg/dL is achieved

Note: I designed the Table 2 from reviewed literature of ABLES/CDC/NIOSH, 2015; CDC Notifiable Condition, 2016; CSTE, 2015, µg/dL = microgram per decillitre.

Blood Lead Levels and Health Implications

Many types of occupational lead exposure had been implicated of posing serious health hazards among the affected workers (Shaik et al., 2014). Exposure to lead could cause a wide range of biological effects depending on individual tolerability, the blood lead level and duration of exposure (Ji et al., 2015; Liu, Chen, & Tian, 2016). Despite well documented health impacts of high blood lead level and effort to curb its use, lead remains a pervasive global hematological, neurological, renal and reproductive toxin capable of causing serious and in some cases irreversible health damage (Alberta Occupational Health and Safety [AOHS], 2013; kuijp et al., 2013). According to Singh et al. (2013), human population is increasingly becoming affected by lead pollutants either occupationally (workers in battery manufacturing units and recycling units) or nonoccupationally (living near factories and indirect use of lead in various home remedies).

Lead is potentially lethal toxin that affects virtually every organ in the human body, it crosses blood-brain barrier to access the central nervous system thereby inflict brain damage, causes nervous system disorder, deteriorate cell functions and a host of neurological disorder (Ji et al., 2015; Kuijp et al., 2013; Liao et al., 2016; Mason, Harp & Han, 2014). Until the lead toxin is eliminated, it will continues to cause serious renal, gastrointestinal, cardiovascular, reproductive and neurological disorder even if only small dose infiltrate the body (Ajayi, Ajayi, & Odusanya, 2014; AOHS, 2013; Kuijp et al., 2013; Liao et al., 2016). The toxicity of lead could generate adverse health effect in every individual, and the severity of overt symptoms worsens with increasing blood lead levels

(AOSH, 2013; Ji et al., 2015; Liao et al., 2016; Patil et al., 2013). The symptoms include mild fatigue, emotional irritability, difficulty in concentration, and sleep disturbances, while moderate symptoms are headache, drowsiness, myalgia, arthralgia, tremor, nausea, decreased appetite, abdominal cramps, diarrhea or constipation, and decreased libido but the severe symptoms include colic abdominal pain, peripheral neuropathy, encephalopathy with seizures, delirium and coma (AOSH, 2013; Ji et al, 2015; Kuijp et al., 2013; Shaik et al., 2014; Singh et al., 2013).

In adult, the absorbed lead could be excreted naturally within a couple of weeks if there is no continue exposure but if there is continous exposure, most of the original lead would be retained, and more will continues to accumulate in a mineralized form in the body tissue that is teeth and bone (Patil et al., 2013; Shaik et al., 2014; Sirivarasai et al., 2013). Children have higher absorption rate than adults and this make them vulnerable to lead toxicity even when exposed to low dose of lead pollutants (Ajayi et al., 2014; Hanna-Attisha et al., 2016; Perry & Amod, 2011). Considering the uniquelead absorption rate in children, relatively low levels of blood lead concentration could lead to permanent intellectual impairment and organ system failure (Ajayi et al., 2014; Hanna-Attisha et al., 2016; Khan et al., 2011; Perry & Amod, 2011). Many studies have indicated that there is no safe threshold for lead exposure as no amount is too small to induce the adverse effect of biological reaction (Kuijp et al., 2013; Sharma, Sharma, Paliwal, & Pracheta, 2011a).

Incidence of Lead Poisoning in Nigeria

The global occurrence of lead poisoning is due to the ubiquitous nature of lead in the environment (Dongre et al., 2011; Riva et al., 2012). The incidence of lead exposure among the lead occupational groups remain a problem in developing countries considering the public health impact (Abdulsalam et al., 2015; Adela, Ambelu, & Tessema, 2012; Haider & Qureshi, 2013; Jangid et al., 2012; Singh et al., 2013). The estimated global burden of diseases related to lead poisoning is 0.6%, with developing countries having the highest incidence (CDC, 2014; Huang et al., 2013; Kasperozyk, et al., 2013; WHO, 2015). A developed countries like United States had achieved a considerable reduction in lead poisoning through improved and effective control method since 1970 (AOHS, 2013; CDC, 2014; CDPH, 2014). There is regulation in place to control lead content in all products so as to reduce the exposure rate, but the lead is still allowed in many products in developing countries (CDC, 2014).

Lead poisoning in Nigeria is a cause for concern as evidence shows that lead pollution is on the rise (Ajumobi et al., 2014). In the year 2010, there was an outbreak of lead poisoning in the villages of Zamfara state in Nigeria as a result of unregulated (illegal) mining of gold ore. According to Ajumobi et al. (2014), 320 adults and 734 children below the age of 5 years out of 5,395 children in in the affected villages of Zamfara state were identified, and confirmed to be killed by lead poisoning, and 2,070 were treated while 3,198 still required treatment for lead poisoning. The situation of lead poisoning crisis was described as unprecedented and despite its critical nature; the situation has not improved as new cases are being reported (Ajumobi et al. 2014).

Dooyema et al. (2012) argued that the death of children of 5 years old and below was due to the occupation of their parents that causes exposure to lead poisoning as a result of processing gold ore within the household compound in north western Nigeria. The similar events also occurred recently in Kaduna and Niger state with 2% of the population of children living in the two states having a high blood level of 30.0μg/dL and adults having blood lead level over 200.0μg/dL (Dooyema et al., 2012). The estimation of acute lead poisoning among battery technicians is hard to calculate due to lack of surveillance systems to monitor lead poisoning among automobile technicians in Nigeria (Abdulsalam et al., 2015). According to Abdulsalam et al. (2015), lead poisoning incidence rate (IR) for battery technicians were 29.6 times higher than other combined (battery workers, 50.2 IR and non-battery workers, 2.1 IR).

The blood lead level of automobile technicians was significantly high with 66.0μg/dL for the organized and 43.5μg/dL for the roadside automobile technicians (Abdulsalam et al., 2015). Singh et al. (2013) stated that the battery smelters, repairers, recyclers and those who work in battery manufacturing company were having high blood lead level above the accepted 40.0μg/dL for an adult that are occupationally exposed. Conclusively, lack of information on safety practices on lead exposure and no or non-implementation of preventive policies to regulate the activity of artisans and industries are the primary cause of continuing prevalence of lead poisoning in Nigeria.

Lead Exposure Routes for Battery Technicians at the Workplace

The low-level environmental exposure to lead is associated with multiple sources including occupational, environmental and home use appliances (AOHS, 2013; Haider & Qureshi, 2013). Lead exposure in general population occurs primarily through ingestion but inhalation contributes to the lead body burden, and is a major contributor for workers in lead acid battery (LAB) occupations that were exposed to lead fumes during manufacturing, smelting and recycling of battery (Adela et al., 2012; AOHS, 2013; Haider & Qureshi, 2013; Pogacean & Pop, 2015). The routes of exposure to inorganic lead amongbattery technicians include ingestion or inhalation of lead particles or through transdermal absorption of organic alkyl lead (Kuijp et al., 2013; Shaik et al., 2014).

The ingestion route of exposure is common among the lead acid battery technicians (Pogacean & Pop, 2015). Adela et al. (2012) argued that 88% of exposed battery technicians had their meal at the workplaces on a regular basis of at least one meal per day; this indicates that significant regular exposure to lead particles does occur through ingestion. According to Pogacean and Pop (2015), lead from workers hands can contaminate food and cigarettes if the hands are not properly washed before the meal. The second routeis inhalation; this occurs during cutting torch to melt leaded solder, heat is generated with vapors, inhalation of small lead particles dust and fumes took place during this process especially when smelting battery lead cell without face mask (Haider & Qureshi, 2013). Also, when there is a lack of ventilation to control exposure to airborne lead particles, and also if there is a lack of decontamination services at the workplace (AOHS, 2013). The inhaled lead particles penetrated deeply into the lungs and the small size allows the body to absorb it quickly and creating the potential for severe acute lead poisoning (Dongre et al., 2011; Jangid et al., 2012; Singh et al., 2013).

The transdermal exposure is the third route in which lead particles penetrate through the skin in a situation where there are no protective clothing facilities at the workplaces (Jangid et al., 2012). Haider and Qureshi (2013) stated that breaking battery or recycling exposes battery technicians to lead particles, not only do batteries contain lead plates; they also contain extremely corrosive hydrochloric acid that is contaminated with lead. According to Shaik et al. (2014), the absorbed lead particles binds to erythrocytes (red blood cell) and could be stored for a an extended period of time in mineralizing tissues (teeth and bones), and then released again into the bloodstream causing most of the toxic effects. The lead contaminants that stored in bones account for more than 95% of the lead burden in adults (Shaik et al., 2014).

Lead Exposure Safety Strategies for Battery Technicians' at the Workplace

Lead intoxication at workplaces of battery technicians is preventable provided integrated preventive measuresare put in place, maintained and sustained (Kuijp et al., 2013; Jangid et al., 2012). According to Alberta Occupational Health and Safety [AOHS] (2013), controlling exposure at the source is the key towards preventing lead poisoning. The safety measures options that applied to the battery technician'sto control lead contaminants properlyat the workplace are listed in figure 2 in the hierarchical order of priority of the required preventive measures:

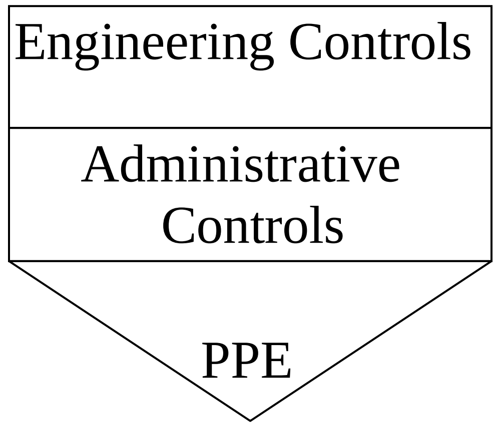


Figure 2. Safety control measures in hierarchical order at the workplace of battery technicians, March 2016.

The engineering control is the mechanical process used to eliminate exposure to lead particles dust or fumes contaminants (AOHS, 2013). In engineering controls, the contaminants are removed from the air or a barrier is created between the battery worker and the contaminants (AOHS, 2013). Alberta Occupational Health and Safety stated that the engineering controls that could be used to prevent exposure to lead include: installation of local ventilation hoods for fumes from soldering operations in battery technicians workshop; installation of dust collection systems onto machines and equipment; carry out shear cutting instead of torch cutting; create enclosures around the work process and use of ultrasonic wet cleaning device for cleaning fumes in the battery technicians workshop should be encouraged. The engineering control would eliminate or greatly reduce the potential hazard when operating properly in battery technician workshop; installation is once and do not place a physical burden on workers like personal protective equipment (AOHS, 2013; Bockelmann et al., 2011; California Department of Public Health [CDPH], 2014; Haider & Qureshi, 2013; Nulhakiem, 2013).

The administrative control would implement work practices that could reduce potential exposure to lead, and these include educating battery technicians so that they understand the hazards associated with lead (AOHS, 2013; ILO, 2012; Nulhaikiem, 2013; Occupational Health Services and Practice [OHSP], 2013). It should be emphasized that there is a need for battery technicians to have sound knowledge of hazards associated with lead exposure by participating in training and monitoring programs (blood lead monitoring) at the workplace (AOHS, 2013; ILO, 2012). Alberta Occupational Health and Safety (2013) stated that the administrative control also emphasize the need for developing and using work procedures that reduce the potential for battery technician’s exposure to lead contaminants. This could be achieved by ensuring proper housekeeping practices are followed at the workplace, and since ingestion is one of the main exposure routes for lead, the importance of personal hygiene needs to be equally emphasized at the workplace (Abdulsalam et al., 2015; Adela et al., 2012; AOHS, 2013; Pogacean & Pop, 2015).

Researchers argued that the level of ingestion of lead contaminants could be reduced to a minimum or prevented if appropriate protective washing facilities are provided, maintained and sustained in and around the workplace environment (Adela et al., 2012; Pogacean & Pop, 2015). Implementing regular hand washing at the workplace could reduce exposure to lead contaminants and is less expensive than engineering control but battery technicians must be properly trained on how to wash hand with soap and water properly, regularly and follow the practices correctly (Adela et al., 2012; Pogacean & Pop, 2015). Abdulsalam et al. (2015) opined that improvements on hygiene practices at the workplace are more effective at lowering blood lead levels than reducing the ambient lead level; the hygienic practices could reduce lead exposure in the workplace especially in developing country like Nigeria where engineering control at the workplace of battery technicians may not be available.

In a situation where engineering control or change of work practices to reduce the potential for lead exposure is not practicable or feasible or they do not reduce the hazards sufficiently then the personal protective equipment is required (AOHS, 2013; CDPH, 2014; OHSP, 2013). The battery technicians need to use respiratory equipment that could filter airborne lead particulates from the air that is breathed in the work environment (Perry & Amod, 2011). Occupational health services and practices recommended personal protective clothing could prevent skin contact and contamination from the lead dust. The protective clothing must be removed before the technicians leave their workshop, and this lead-contaminated cloth must not be laundered at home. Although the use of personal protective equipment could initially seem less costly but could create a hazard to technicians such as heat stress, limited vision, and allergic reactions to the equipment materials and these issues need to be evaluated when using PPE at the workplace (AOHS, 2013).

Furthermore, developing effective regulations and regular progress monitoring should be instituted at the workplace to control lead poisoning (AOHS, 2013). The implementation of large-scale health screening and lowering all pervasive and hidden epidemics will prevent lead exposure, and its long-term impacts on the society (AOEC, 2013). The workplace environment of the battery technicians need to be improved, to avoid “non-fit” environment that could expose the battery technicians to hazard (Perry & Amod, 2011). The self-protective safety behavioral practices need to be improved upon by the battery technicians by imbibing positive behavioral attitude towards safety practices at the workplace (Adela et al., 2012; Haider & Qureshi, 2013).

In conclusion, the occupational lead exposure in many developing countries is entirely unregulated and often with no monitoring of exposure at the workplace (Abdulsalam et al., 2015; Patil et al., 2013; Rival et al., 2012). The legislation under Alberta Occupational Health and Safety Code has a general and specific requirement related to lead exposure (AOHS, 2013). In Nigeria, there are numerous small-scale battery technicians’ workshops that uses lead acid based materials that posea health risk to them, but presently there are no workplace legislation and regulations directed towards these categories of workers against lead exposure (Abdulsalam et al., 2015). The ministry of labor in Nigeria does not have data on lead poisoning and no occupational exposure limits (OELs) are provided for lead compounds, so an appropriate and cost-effective integrated preventive and control measures is urgently required.

Responsibilities of Employers on Lead Poisoning Safety at the Workplace

The National Institute for Occupational Safety and Health stated that employers have a responsibility to ensure that workers are protected from harmful lead exposure in their workplace (NIOSH, 2015). According to US Department of Labor and Industries, the responsibility of employer’s includes ensuring that lead in the air around workplace environment is not at hazardous levels of greater than fifty micrograms per cubic meter ($50\mu g/m^3$) averaged over an eight-hour period (CDPH, 2014). The employers need to maintain and sustain a safe and healthful workplace by complying with safety standard established to prevent harmful exposure to lead through provision of protective measures and equipment at no cost to employees (AOHS, 2013). According to California Department of Public Health (2014), the employers need to notify their employees about lead hazards by pasting a poster at visible lead work area at eye level, and for lead-contaminated clothing, equipment and about the central nervous system, and reproductive health effect of lead in a language understandable to the workers.

A copy of air monitoring results, lead safety standard and medical monitoring must be made available to workers upon request (AOEC, 2013; AOHS, 2013). The employers must be ready to fund the blood lead testing, medical exams, and consultations for employees that are potentially expose to lead above $30\mu g/m^3$ in the air per day, and must be willing to transfer such worker out to non-lead exposed job without loss of pay and benefits, that is medical removal (AOEC, 2013; AOHS, 2013). In Washington DC, the worker occupationally exposed to lead poisoning has the right to file a confidential complaint with the US Department of Labor and Industries if workers believe there may be a serious hazard (USDLI, 2015). The worker also has right to file a complaint if he/she believes being discriminated against for exercising one of his Washington Industrial Safety and Health Act (WISHA) – protected right (USDLI, 2015).

In developing countries like Nigeria, the situation differs as the workers occupationally exposed to lead poisoning do not have a special occupational hazards complaint center, though there is Public Complaint Commission where such matter could be reported, it was not categorically stated in the Act that established the commission that workers exposed to lead poisoning could file a complaint. The employers often do not carry out regular medical check up for workers exposed to lead poisoning, and presently no data is available on occupational lead poisoningfrom Federal Ministry of Labor in Nigeria.

Responsibilities of Battery Technicians' on Lead Poisoning Safety at the Workplace

The battery technicians have the responsibilities of protecting themselves by complying with safety practices at the workplace through improved behavioral and psychosocial factors (Haider & Qureshi, 2013; Kuijp et al., 2013). The battery technicians should ensure a fit workplace that is not overexposed to lead particles through the use of ventilation equipment (Perry & Amod, 2011). Hands and face washing before food/drink or smoking is very vital to ascertain safety on lead poisoning at the workplace (Adela et al., 2012; Pogacean & Pop, 2015). Use of separate work cloth and shoes/boots while at work, and cloth wear from home should be kept in a clean place (AOHS, 2013). The battery technicians need to avoid stirring up lead-containing dust with dry sweeping or blowing; wet cleaning and vacuuming are safer (Haider & Qureshi, 2013). Work cloth should be launder at work but if there is a need to take work clothes home, it must be washed and dry separately (AOHS, 2013).

It is the responsibility of battery technicians to check the work area for lead dust and fumes and find out how to avoid exposure by using PPE and engineering control (Perry & Amod, 2011). Personal protective equipment must be properly selected, used and maintained, and workshop "Code of Practices" must be developed and followed especially for technicians that have more than a small amount (10kg) of lead at the work site (OHSP, 2013). The battery technicians need to be aware of a lead exposure control plan in which suitable showers, change rooms, and other facilities must be provided to allow technicians to remove lead contaminants before leaving work site (AOHS, 2013). Thematerial and articles that have been properly decontaminated or cleaned can be taken from the workshop by the technicians (AOHS, 2013). No battery technician should eat, drink or smoke in an area of the workplace contaminated with lead dust/particles/fumes (Adela et al., 2012).

Review of Literature With Similar Methodology and Construct

Abdulsalamet al. (2015), conducted a study on factors that are related to lead exposure, determined and compared the blood lead levels of automobile technicians in the organized and roadside garages in two local government areas of Lagos state, Nigeria. The researchers applied cross-sectional and multistage sampling method to select 353 automobile technicians that include; mechanic, spray painters, panel beaters, auto electricians, upholstery makers, radiator repairers, battery chargers, welders and other technicians. The close-ended structured questionnairewas adapted to collect data for the survey (Abdulsalam et al., 2015).

The study revealed high prevalence of elevated blood lead levels among the automobile technicians in the organized setting compared to roadside setting. The median blood lead level of the organized group (66.0µg/dL) was found to be significantly higher than that of the roadside group that had median blood lead of 43.5µg/dL (Abdulsalam et al., 2015). The safety practice on lead poisoning among the participants was low 23.5% (82.9 of 353) and the primary predictor of safety practice was the blood lead levels of technicians in the study settings (Abdulsalam et al., 2015). The study implies that constraint at the workplace is a major issue as it affects the rate of utilization of protective facilities. If there is a provision of appropriate and safe workplace condition, there could be a reduction in the rate at which the automobile technicians are being exposed to lead contaminants.

Availability of safety facilities had been seen to be associated with safety practices at the workplace (Adela et al., 2012; Pogacean & Pop, 2015). Availability of safety facilities could reduce the suffering, health problem, long-term effect of lead poisoning in the body, and the money that would be expended in managing high lead concentration in the blood of the affected technicians (Singh et al., 2013). Availability of the safety facilities could increase the knowledge of the technicians on safety practice at the workplace (Haider & Qurashi, 2013). It could encourage the technicians to participate in safety program since the availability of safety facilities could give them a greater chance of handling the safety equipment and opportunity of asking questions, and getting informed (AOHS, 2013).

Adela et al. (2012) conducted a cross-sectional survey on occupational lead exposure among automotive garage workers - a case study for Jimma town, Ethiopia. In addition to Blood Lead Levels (BLL) analysis, data on some risk factors such as chewing, smoking, and eating of food at the workplace were gathered using a structured questionnaire for 85 automobile technicians. 53% (48 of 85) of the participants had BLL over 20.0µg/dL, and the blood lead levels of individuals who chew at the workplace was found to be significantly higher compared to the blood lead levels of participants who do not chew at the workplace (Adela et al., 2012). The implication of this study is that workplace conditions and personal hygiene were associated with high blood lead levels among the automobile technicians. Conducive work environment and improved personal hygiene could reduce exposure to lead poisoning (Pogacean & Pop, 2015). Workplace eating, chewing, smoking, and lack of awareness about the ill-health effects of lead contaminants, and routes of entry into the human body has contributed to the easy entry of lead into the body of automobile technicians which resulted in accumulation and elevation of blood lead levels (Adela et al., 2012).

Improper or lack of adequate control measures, non-provision of safety equipment, lack of monitoring, no safety training, and health status of the battery technicians are safety practices quality indices of lead poisoning at the workplaces (kuijp et al., 2013). Researchers had applied cross-sectional research design to determine the effect of lead poisoning on automobile technicians (Dongre et al., 2011; Liao et al., 2016; Singh et al., 2013). Singh et al. (2013) applied cross-sectional research designed to evaluate the blood lead levels (BLLs) and plasma marker of oxidative stress in the individual that were occupationallyexposed to lead dust/fume. A total of 38 lead exposed workers (18-battery charges, 10-spray painters, and 10-mehanic) were recruited for the study and consent collected freely from the participants (Singh et al., 2013).

The researchers determined the sample size, and the sampling technique used for the selection of participants was systematic random sampling (Singh et al., 2013). Singh et al. (2013) associated the effect of lead toxicity with the depletion of the body antioxidants. The oxidation stress index increased in battery technicians, Spray Painter, and mechanics, and the mean value of plasma was significantly decreased by 75% in all member of the group when compared with the control group (Singh et al., 2013). Lead initiates its damaging effect on the human body by binding to red blood cell (Erythrocytes) and ruptures their membranes (Singh et al., 2013).

In a study conducted by Dongre et al. (2011), the researchers' used a quantitative, cross-sectional survey approach to assess the impact of chronic lead exposure on systolic and diastolic blood pressureof automobile workers in the north Karnataka, India. The participants involved in the study were 30 automobile workers with occupational exposure to lead pollutants compared to normal 30 healthysubjects with nonoccupational lead exposure but adults of the same age rangeand similar characteristics (Dongre et al., 2011). Questionnaires were used to collect the data, and consent was obtained from all the automobile technicians and the control subjects (Dongre et al., 2011). According to Dongre et al. (2011), systematic random sampling was used to select the participants; it was found that systolic blood pressure (5.32%, $p < 0.05$) and diastolic blood pressure (5.87%, $p < 0.05$) were significantly increased in the automobile workers compared to the blood pressure of the control groups.

Liao et al. (2016) investigated the relationship between occupational lead exposure (estimate of cumulative exposure to lead fumes and lead dust) and cancer incidence at the five selected centers in Shanghai, China using prospective cohort study design to follow the participants. The Shanghai women (n=73, out of 363) were successfully monitored between the year 1996 and year 2000, and the Shanghai men (n=61, out of 379) were successfully monitored between the year 2002 and 2006.

According to Liao et al. (2016), the cohort specific relative hazard rate ratios (RRs) at 95% confidence intervals (CIs) was used to compare the exposed and unexposed participants using Cox proportional hazards regression combined with meta-analysis. The proportion of Shanghai women and Shanghai men participants with estimated occupational lead exposure were 8.9% and 6.9% respectively, and the findings suggested that lead exposure was positively associated with the risk of several cancers in women and men studied (Liao et al., 2016).

The implication of the above studies is that lead toxicity requires immediate and active safety measures among the lead occupationally exposed workers considering its biological mechanism in the human body (Dongre et al., 2011; Kuijp et al., 2013; Liao et al., 2016; Liu et al., 2016). According to Dongre et al. (2011), battery technician's education may not be a determinant of the health effect of lead toxicity. Researchers suggested that an appropriate and cost-effective preventive and control measures are required in all battery plants, workshops, and that compliance with safety measures by the battery manufacturers, repairers, and recyclers is the key decision towards averting the negative health effect of the lead toxicity (Liao et al., 2016; Liu, et al., 2016; Pogacean & Pop, 2015; Singh et al., 2013). Furthermore, the occupational healthcare services providers need adequate knowledge and proper diagnostic procedures to appropriately attend to the problem of lead poisoning (AOEC, 2013; Dongre et al., 2011; Kuijp et al., 2013).

Improper utilization of safety facilities and equipment with negative self-protective behavioral practices at the workplace is a predictor of the health status of the lead occupationally exposed workers (Pogacean & Pop, 2015). The Ethiopia study has shown an association between lead exposure and health risk of neurotoxin among urban and rural inhabitants, and the need for utilization of safety measures (Getaneh et al., 2014). The finding of this study is consistent with the conclusion of another study conducted in Shanghai, China, that associate occupational lead exposure with selected cancers of the stomach, lung, kidney and meninges in men and women (Liao et al., 2016). Adequate utilization of safety measures with improved safety practices at the workplace could curtail the long-term health effect of overexposure to lead poisoning among battery technicians (Pogacean & Pop, 2015).

The battery technicians should have received information concerning the associated health effect of lead poisoning during safety training sessions so that they could have acquired useful information on safety practices at the workplace. Adela et al. (2012) argued that nonspecific symptom of lead poisoning is a problem as battery repairers could not associate the occurrence of wrist drop, tingling, numbness in finger and hands, nausea, abdominal discomfort and decreased libido to the effect of lead poisoning. In the study conducted in Ethiopia, the proportion of individual affected by the nonspecific symptoms were those technicians with BLL of 16.0 to 20.0µg/dL and above which could be a clear indication of the negative health impact of BLL as low as 10.0µg/dL (Adela et al., 2012). The battery chargers in Lagos, Nigeria are at an advantage position since they are located in a megacity with the presence of professionals and government. In comparison with the rural areas, the presence of professionals and the government could have a positive influence on the rate of utilization of medical facilities for screening and monitoring of their blood lead levels.

The battery technician's education level had been found not to be associated with safety practices at the workplace in Pakistan and Ethiopia (Getaneh et al., 2014; Haider & Qureshi, 2013). This finding contrast to the result of research conducted in Nigeria and India where the education level of the battery technician's positively affected safety practices and use of PPE (Dongre et al., 2011; Singh et al., 2013). The difference might be due to the fact that battery technician's education level was very low in Pakistan and Ethiopia where the studies were conducted, the impact of the few educated technician's made no noticeable difference. The design of the study was a cross-sectional survey and multistage sampling method was used in which the population was divided into tertiary, secondary and primary units before the final sample frame were drawn using systematic sampling technique. The accurate population selected by random sampling method in this study could be a positive influence for the generalization of the findings (Getaneh et al., 2014; Haider & Qureshi, 2013).

The battery technician's knowledge of the importance of safety practices and education are the significant predictor of adherence to safety practices at the workplace (Pogacean & Pop, 2015). Battery technician's age, marital status, years of experience and location are not significantly associated with adherence to safety practices at the workplace (Haider & Qureshi, 2013). According to Haider and Qureshi (2013), 83.4% that is n=165 of 200 of battery technicians studied in Pakistan do not adhere to the safety practices at the workplace. The study was a cross-sectional design and it was carried out in Karachi, Pakistan. Haider and Qureshi (2013), observed that nonadherence to safety measures by battery technician's was significantly associated with the lack of safety facilities, and lack of knowledge of the importance of safety practices at the workplace.

The above finding is similar to the result of the study which observed that safety practices at the workplace was associated with battery technician's knowledge of the importance of safety practices, and health implication of the nonadherence (Adela et al., 2012; Pogacean & Pop, 2015). Chi-square statistical test was used to establish an association that exists between variables. This statistical test gave details about the crude association that exists between the variables. The study also used the multivariate statistical test to analyze dependent variable due to many covariates that demand a multivariate statistical technique for analysis (Pogacean & Pop, 2015).

Researcher in Oyo state, Nigeria assessed the health impact of lead poisoning on workers of a battery recycling company and determined the impact of self-protective safety behavioral factors on safety practices (Odesanyaolu, 2011). The researcher used cross-sectional survey design and determined the sample size (86 battery workers aged 23 to 57 years were among the 339 studied population), and systematic sampling technique was used to select final subjects (Odesanyaolu, 2011). The data was collected using administered questionnaire as an instrument with many of the questions being close-ended (Odesanyaolu, 2011).

In the section of the instrument that asked questions on knowledge about the safety practices on lead poisoning. Odesanyaolu (2011) asked 5 questions which are as follows: 1. Mention the appropriate safety equipment for protection against inhalation of lead fumes, with respirator being the correct answer. 2. Reasons for wearing a respirator while smoldering battery lead cell, which is for the prevention of inhalation of lead fumes/dust. 3. The appropriate time to use PPE at the workplace and to be used regularly at the workplace is the expected answer. 4. Able to mention at least three common symptoms of lead poisoning like an abdominal ache, fatigue, headache, fell dizziness, and numbness of extremities.

With greater doses of lead poisoning, the adult could experience personality changes and acute encephalopathy (Ji et al., 210; Liao et al., 2016). Lead poisoning causes coma and convulsion could occur in children, behavioral problem and reduced intelligent quotient (IQ) at low lead concentration and all these signs are due tothe neurologic toxicity of lead in the central nervous system (Odesanyaolu, 2011). 5. stating the diseases that were associated with lead poisoning and this include diseases like hypertension, cancer, and central nervous system diseases. Participants who got the answers right were scored correct and put on scale “1” while participants that provide the wrong answer were score incorrect and put on scale “0.”

Battery technicians’ educations, knowledge of health effects of lead poisoning are significantly associated with utilization of safety measures (Odesanyaolu, 2011). The researcher used a binary scale to obtain information; the response is rated as “0” for the incorrect answer while “1” was designated to correct answer. The researcher found that battery technicians’ education level was significantly associated with the knowledge of health effects of lead poisoning (Odesanyaolu, 2011).

There was an association between knowledge of safety measures at the workplace and health status of the battery technicians. Unavailability of safety facilities and lack of safe working conditions could be demoralizing to battery technicians and cause failure to adhere to safety practices (Pogacean & Pop, 2015). Lack of PPE is one of the situations that could result in nonadherence to safety measures (Pogacean & Pop, 2015). Another factor that could lead to nonadherence to safety practices at the workplace is the lack of monitoring and enforcement of regulation by government officials and occupational professionals, this was associated with safety practices in Lagos state, Nigeria (Abdulsalam et al., 2015). The result was from a cross-sectional survey of 353 automobile technicians and could likely be generalizable.

In Lagos state, Nigeria, Adebola (2014) determined the safety practices of petroleum oil workers on occupational hazards and assessed factors that influence utilization of safety facilities at the workplace (Adebola, 2014). The sample size for the study was determined, and selection of participants was done using systematic sampling method, and data were collected with structured questionnaire that have close-ended questions (Adebola, 2014). The dependent variable (safety practices) was measured using questions on safety practices section of the questionnaire to determine the safety practices status. The participants that scored $\geq$ 70%, that is answered 7 correctly out of 10 questions was rated good practice, participants that scored = 50% that is answered 5 correctly out of 10) questions was satisfactory, while participants that scored < 50% (4 out of 10) questions were rated poor practices. The questionnaire equally measured the knowledge of the petroleum oil workers on safety practices at the workplace, knowledge of health impact of lead contaminants from petroleum products, knowledge of the importance of utilization of PPE, knowledge of the importance of maintaining personal hygiene at the workplace were all independent variables (Adebola, 2014). Multivariate logistic regressions analysis method was used to analyze the predictions of safety practices among the workers while the binary univariate statistical analysis was used to analyze crude association that exists between the categorical variables.

The safety practices compliance rate was 26.5% (97 of 336); there was an association that exists between safety practices and worker's education level, and workplace conditions adjusting for other covariates (Adebola, 2014). The safety practice was significantly associated with the workers knowledge of the benefits of safety practices at the workplace, knowledge of the health implications of an occupational hazard, and utilization of PPE (Adebola, 2014). Adebola (2014) found out that workplace location and demographic characteristics of the workers are not significantly associated with safety practices at the workplace.

Training of the battery chargers technicians and knowledge of the safety measures have an association with safety practices at the workplace (Hess, Cooper, Smith, Trueman, & Schutkowski, 2013; Pogacean & Pop, 2015). Training on safety practices indicates that battery technicians had the opportunity of receiving information on safety measures (Pogacean & Pop, 2015). Safety measures information for technicians with necessary safety facilities at the workplace could create awareness and positive change in attitude towards improved safety practice (Hess et al, 2013; Pogacean & Pop, 2015). The implication of the finding of these researchers is that there is an association between training, positive behavioral change and safety practices at the workplace (Hess et al, 2013; Pogacean & Pop, 2015). The study could be generalizable but may not indicate causality being a community based survey.

A descriptive, cross-sectional study was conducted by Tuakuila, Lison, Mbuyi, Haufroid and Hoet (2013) to determine the association between workplace conditions and safety practices on lead poisoning among the occupationally exposed population of Kinshasa, the capital of the Democratic Republic of Congo. The sampling method applied was systematic sampling technique to select 275 participants who were stratified by age (20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 and above). Data were collected with questionnaires that were administered to the surveyed population (Tuakuila et al., 2013).

Personal protective equipment was the dependent variable and its rate of utilization was measured with oral evidence of compliance with the workplace safety standard (Tuakuila et al., 2013). The demographic characteristics of the participants were the independent variables and the reasons for nonutilization of the PPEwhere applicable include lack of training, poor safety practices knowledge, and workplace conditions (Tuakuila et al., 2013). The analysis of the results was done with descriptive statistics in which the age and gender were disaggregated (Tuakuila et al., 2013).

The finding of the study revealed that the rate of utilization of the PPE at the workplace by battery technicians was 35.6% (96 of 275), and the workplace safety facilities was 41.6% (119 of 275; Tuakuilaet al., 2013). The study also revealed that the reasons for nonutilization of the PPE at the workplace were due to nonavailability of the

PPE, lack of money to purchase the PPE, and lack of awareness of the toxicity of lead fumes/dust. Tuakuila et al. (2013) stated that knowledge deficit of the health implication of lead toxicity and lacks of money to purchase the PPE were the reasons for poor safety practices at the workplace. Lack of money to purchase PPE mighty be related to the small income generated being a small-scale business, and the knowledge deficit on awareness of the toxicity of lead fumes/dust have shown to influence safety practices at workplaces (Abdulsalam et al., 2015; Singh et al., 2013). This study tested hypotheses using variables of interest and it was a descriptive cross-sectional study.

Pogacean and Gurzau (2014) computed the rate of utilization of PPE, availability of the appropriate safety apparatus and social demographic determinants of safety practices among battery technicians in India. The study focus on the workplace conditions and the researchers used a cross-sectional method to conduct the study, and systematic sampling technique was applied to select 96 participants. The workshop environment was the sources of information on workplace conditions. Questionnaires were administered and data collected on demographic characteristic and reasons for nonavailability of the required safety facilities at the workplace, where applicable for the participants. Multivariate and univariate logistic regressions analysis were employed to analyze the data.

The rate of utilization of PPE was 24.1% (24 of 96), and availability of appropriate safety apparatus was 19.5% (18 of 96; Pogacean & Gurzau, 2014). The battery technician’s years of experience, education level, and workshop environment positively influence safety practices (Pogacean & Gurzau, 2014). Conversely, lack of training and awareness ofthe utilization of safety apparatus negatively affected safety practices, and even responsible for nonutilization of the safety device, where applicable for the participants (Pogacean & Gurzau, 2014). Battery technician's educational level is associated with safety practices (Pogacean & Gurzau, 2014).

The finding of this study was consistent with that of another study conducted in South Africa which stated that automobile technicians with low educational background below high school level are more likely to exhibit noncompliance with safety practices at the workplace than those with higher education level (Hess et al., 2013). The battery technicians may see the use of safety apparatus as a stress considering the inconveniences of wearing PPE, and the likely allergic reactions, and consequently, battery technicians may not comply with the regular and appropriate use of PPE (Hess et al., 2013). This study implies that there is a need to give proper and adequate information on the toxicity of lead contaminants, the health hazards, and the associated economic implications of noncompliance with safety practices on lead poisoning. The study was a cross-sectional survey, questionnaire was used to collect data and this could have excluded the real actions of the participants and may result in bias estimates.

Kalahasthi, Barman, and Rao (2012) assessed the relationship between blood lead levels and hematological parameters among leadacidbattery workers working in a storage plants located in Tamilnadu, India. The study was a cross-sectional design, and a total of 391 workers from 8 different sections of the storage plant company participated in this study that determined factors associated with safety practices at the workplace (Kalahasthi et al., 2012). The participants involved in this study were aged 20 – 67 years.

The questionnaire was used for data collection. The workplace facility and the attitude of the workers were assessed along with the demographic information of the participants. Training willingness, provision of information on safety practices and toxicity of lead poisoning, and related data were collected. The workplace environment and availability of safety apparatus were assessed by the researchers to verify the technician's claims. The multivariate logistic regressions and chi-square statistical test were used to establish the associations that exist between the variables.

Kalahasthi et al. (2012) found that 20.2% (78 of 391) of the participants complied with safety practices. Findings indicated that utilization of safety facilities is significantly associated with knowledge of health implication of lead toxicity, availability of PPE, years of experience, educational level, the level of communication, and location of the workshop (Kalahasthi et al., 2012).The multivariate logistic regressions results on availability of protective devices was (*OR*=2.1; 95% CI: 1.23, 3.43); education level was (*OR*=2.162; 95% CI:1.346, 3.846); and years of experience was (*OR*=0.36; 95% CI:0.281, 3.748) were all statistically significant. The study findings were similar with that of studies carried out in Ethiopia and Nigeria. The studies established an association that exists between utilization of protective devices and knowledge of safety practices, workers education, availability of safety facilities and good training on the use of lead protective devices (Adebola, 2014; Adela et al., 2012).

Methodology and Approaches

The quantitative, cross-sectional design methodology could make use of the secondary data collected through survey by Occupational Safety and Health Administration (OSHA). Similarly, data from Occupational Lead Poisoning Prevention Program (OLPPP) survey, United State Center for Disease Control and Prevention (CDC) survey, ABLES program survey, and record from Association of Occupation and Environmental Clinics (AOEC) have been reported to be used extensively by researchers. Another methodology used is the direct gathering of primary data from the community based survey. The data were reported studied by applying cross-sectional design and quasi-experimental method with the control group.

Furthermore, cohort study design had also been used to determine the long-term health implication of lead poisoning on the workers that are occupationally exposed to lead dust and fumes at the workplace. Researchers have argued and proved that administrative data are incorrect and often unreliable in some quarters (Kuijp et al., 2013; Shaik et al., 2014). The data may not be the exact representation of the target population and could be suffering from accuracy, especially in most developing resource poor countries where accurate censuses do not exist (Perry & Amod, 2011). Administrative data from the service provider may lack the relevant social demographic information necessary to determine lead poisoning safety practices of the occupationally exposed workers (Margaret, 2013).

Bakulski et al. (2014) applied Indian National Occupational Health Survey (INOHS) for three consecutive rounds to assess disparity in safety practices among lead occupational exposed workers concerning small, medium and large-scale battery manufacturers. The three rounds of INOHS survey conducted between 2000 and 2014 were the sources of the data (Bakulski et al., 2014). According to Bakulski et al. (2014), the dependent variable which was safety practices was defined in the study and measured from INOHS data. Demographic characteristics of the respondents which formed independent variables were also obtained from INOHS data (Bakulski et al., 2014). Chi-square statistics was tested for differences, and binary logistic regression was used to determine the change in safety practices with relatives to each independent variable (Bakulski et al., 2014).

The safety practices between small, medium and large-scale battery manufacturers in different states of the country was significantly different across the states, and it was found that in the state of Combitore the safety practices compliance rate was less than 25% while Tamal, Nada and Gao compliance rate were above 40% (Bakulski et al., 2014). The location of the factory and technicians education level were significantly associated with safety practice, the workers in the battery factory in urban area comply with safety practices compared with their rural counterparts that had low compliance level (Bakulski et al., 2014). The occupational health and safety data had been criticized for use to assess the rate of utilization of PPE as technicians may not be able to recall vividly the of the rate of utilization of PPE in the pastand this may result in the biasof the estimated rate (Patil et al., 2013). It is noted that there may be difference in the information that could help better in the understanding of safety practices at the workplace (Bakulski et al., 2014).

California Department of Public Health (2014) under the hospice of Occupational Lead Poisoning Preventive Program (OLPPP) determined the safety compliance rate and availability of safety equipment at the workplace of automobile technicians in California, USA using three sources of data. According to California Department of Public Health, the data on blood lead levels of 385 technicians studied in 2008 were collected from physician's office on occupationally related diseases records. The demographic and socioeconomic information used in the study were obtained from census data (CDPH, 2014). The administrative data was validated by conducting a telephone interview with the selected cohort group.

The logistic regressions statistical analysis was used to test the association that exists between safety practices at the workplace and blood lead level as the independent variable (CDPH, 2014). The safety practice compliance rate was 49% (189 of 385) among technicians aged 40-69 years and 40% (160 of 385) for technicians' age 20-39 years (CDPH, 2014). The technicians that combined both occupational and family medicine services tend to comply with safety practices at the workplace than those technicians that used only family medicine services (CDPH, 2014). The safety practice at the workplace is significantly associated with socioeconomic status (CDPH, 2014).

The implication of this study is that safety practices on lead poisoning could be influenced by various factors depending on the location where the study is being conducted, whether in the developed or developing country. Furthermore, the accuracy of the administrative data was verified by the investigator with telephone survey, and this confirmed one of the disadvantages of administrative data on the safety practices study.

Another issue in this study is that information used to measure study variables was from multiple sources. Administrative data from a single source may not provide the required demographics characteristics of the subjects.

Getaneh et al. (2014) conducted a study on safety practices on lead exposure among automobile technicians using a cross-sectional survey. The study determined the factors that influenced technicians' belief on safety practices and refusal or nonutilization of personal protective equipment (Getaneh et al., 2014). Data on safety practices and nonutilization of personal safety apparatus, and belief of the technicians were collected and analyzed. The difference in belief of the technicians was tested with the Chi-Square statistical test (Getaneh et al., 2014). The technicians that refusedto use personal safety apparatus may not believe in the safety practices at the workplace and the associated health benefit, and this could affect their compliance with the utilization of PPE (Getaneh et al., 2014). This study is an example of a cross-sectional analytic study, and the limitation of this study is that data on the belief of the technician may not capture their real opinion due to gap in knowledge of lead poisoning safety practices.

Haider and Qureshi (2013) conducted a cross-sectional descriptive survey in Pakistan on the hematological effect of lead poisoning and safety practices among battery repairer and recycling workers in Karachi, Pakistan. The purpose of this study was to assess awareness and attitude toward safety practices at the workplace of technicians who are occupationally exposed to lead poisoning. Thirty- five items questionnaire was used to collect data from 200 participants (100 battery workers and 100 healthy subjects of the same age range as control group but with different occupation). The safety practice was

30% (30 of 100 battery workers). The majority of the technicians have a low level of awareness on safety practices on lead poisoning and the toxicity 10.1% (10 of 100), and the participants attitude towards safety was poor as they attributed safety practices to their religion and belief in god protection (Haider & Qureshi, 2013).

Researchers conducted a cross-sectional descriptive survey in Nnewi town, south eastern, Nigeria to determine the blood lead levels of automobile techniciansand petrol station attendants and the reasons for noncompliance with safety practices (Ibeh, Aneke, Okocha, Okeke, & Nwachukwuma, 2016). Two hundred and ten automobile technicians were selected with systematic random sampling technique (Ibeh et al., 2016). The researchers used questionnaire with a close-ended questions to collect data from the studied participants. Safety practices was low with only 12.45% (23 of 200) of the participants complied, 82.4% (163of 200) of the participants do not practice safety at the workplace while66.7% (130 of 200) of the participantsdo not have safety equipment at their workplace (Ibeh et al., 2016). The common reasons for not practicing safety at the workplace were the lack of information and money to purchase safety equipment (Ibeh et al., 2016).

The safety practice at the workplace among the automobile technicians was far below the expected achievement in occupational hazard safety practices, and it was reported that Nnewi is a small town; the study showed this as a disadvantage in term of occupational safety services that could be available compared tothe urban area (Ibeh et al., 2016). The survey was community based, limited to estimate population and sample size was determined and administrative data was used instead of official population census of the district that would enable the researchers to avoid high propensity for error (Ibeh et al., 2016). The limitation of this study includes inaccuracy of technician recall of safety practices at the workplace (Ibeh et al., 2016).

The researchers in India have used a quasi-experimental design toassess the impact of lead poisoning at the workplace. The researchers combined interventions programs: like conducting awareness and educational program about lead exposure, intervention on engineering and administrative controls, and use of respirator to determine the effect of lead poisoning on biological monitoring among lead battery workersat the workplace (Kalahasthi et al., 2016). The researchers conducted a random sampling to select 397 technicians into the pre-intervention and post-intervention group (*n*=213, *n*=203) respectively. Trained occupational health workers administered a designed educational intervention, ensured installation of engineering and administrative controls, and use of respirator plus other PPE mandated on the intervention group. The post-intervention safety practices assessment was conducted on the participants after one year of combinedintervention by determined and compared the biological parameters of the lead battery workers at their workplace pre-intervention and post-intervention (Kalahasthi et al., 2016).

The safety practice at the workplace among the post-intervention group was (147 of 203, 72.1%) by the end of the twelve months, and it wasstatistically significantly higher than the safety practices among the pre-intervention group (10.6%, 21 of 213; Kalahasthi et al., 2016). This studyimplication is that the rate of utilization of PPE among the post-intervention group was significantly higher than those of the pre-intervention group. The study emphasized the impact of understanding and knowledge of safety practices among the workers as the key factor that could influences safety practices at the workplace as other studies did (Kalahasthi et al., 2016). The quasi-experimental design could have suffered from maturation threat in which participants could dropout in the follow up. Furthermore, the fact that the investigators did not blind the participants before applying treatment (combined intervention programs) could create a bias in the results.

Rationale for the Study Variables

Independent Variables

The independent variables in this study are battery technicians' workplace conditions, technicians' blood lead levels, technicians' education level, technicians' knowledge of the importance of safety practices and perceived risk of lead poisoning. The work condition is becoming a topical issue in occupational health and safety practices on lead poisoning program (Kalahasthi et al., 2016). The workplace condition can be defined as the cognitive comparison of the technicians work environment experience with technician's expectation (Kalahasthi et al., 2016). The occupational safety services stipulated by the occupational safety regulating body could only hold much weight or influence the safety practices at the workplace if a safe working environment is provided (Pogacean & Gurzau, 2014). In most developing countries of the world like Nigeria, the safety decision enforced by the regulating body on lead poisoning matters, and could not be disregarded as this could influence occupational safety practices at the workplace of occupationally exposed workers (Ibeh et al., 2016).

Previous studies have reported the importance of regulating body, safe work environment and technicians education on the utilization of the PPE, and that these factors have contributed positively to the control of lead poisoning among the occupationally exposed workers (Ajugwo et al., 2014; Pogacean & Gurzau, 2014). The employers could support lead poisoning prevention programs by providing and encouraging use of PPE and ensuring availability of safety facilities at the workplace; all these could improve the compliance rate and self-protective safety behavioral change of battery technicians (Kalahasthi et al., 2016).

Many researchers have studied factors that could influence the utilization of the safety equipment, and the provision of a safe work environment (Adelu et al., 2015; Kalahasthi et al., 2016). In their study, it was hypothesized that technician's workplace condition, blood lead levels, education attainment, the location of workshops and knowledge of the importance of the safety practices on lead poisoning at the workplace could influence the technician safety practices and rate of utilization of PPE.

Dependent Variables

In this study, the first dependent variable is the safety practices status of the battery technicians, whilethe second dependent variable is the battery technician's utilization of PPE. The safety practice of battery technician is a necessarystep and precaution applicable to the safety at the workplace (Kalahasthi et al., 2016; Pogacean & Pop, 2015). This term is known as positive self-protective safety behavioral practices, and up to date compliance with all required safety practices, and utilization of PPE at the workplace (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014). In Nigeria, this is a situation whereby a battery technician completely adheres to the acceptable safety practices standard at the workplace and use PPE regularly at the workplace (Abdulsalam et al., 2015).

Furthermore, the workplace environment should be conducive to the safety practices with the availability of all required safety installations: engineering and administrative controls, and apparatus that are suitable for protection of the battery technicians (Kalahasthi et al., 2016; Pogacean & Pop, 2015). The measure of safety practicesat the workplace is an important variable (index) to assess the performance of occupational safety program (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014). The index (safety practices) measurement is a process of evaluation of the occupational safety program applicable at the workplace, locality or country (Ajugwo et al., 2014; Kalahasthi et al., 2016). The adherence to safety practices at the workplace of battery technicians is necessary to safeguard the health hazards associated with the exposure to lead poisoning, and prevent technicians from developing occupational diseases that were attributed to lead toxicity in Nigeria (Abdulsalam et al., 2015; Ajugwo et al., 2014). Compliance with standard safety practices at the workplace could help to protect the technician's health and reduce the burden of the lead related diseases (Ajugwo et al., 2014; Kalahasthi et al., 2016).

Provision of safe working environment that is conducive and making PPE available along with an improvement in self-protective safety behavioral practices at the workplace could influence safety practices, and improve compliance among battery technicians (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014). The rate of utilization of

PPE at the workplace could enable occupational safety and health officer to know whether the technicians attained safety practices status, if the use of PPE at the workplace is being done in conformity with acceptable norm for safety standard on lead poisoning (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014).

Wheresafe environment and PPE are lacking, investigators are forced to assessbattery technicians by taking the history of safety practices, and this method of data collections could posit a bias in the estimation of the safety practices (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014). Most researchers had described the safety practices variable, but only a few of them have analyzed the level of compliance among lead exposed population. Furthermore, safety practices should also refer to safety information that should be pasted on the entrance door and it must be visible at the work area to provide safety assessment level, utilization, and validity of safety practices at the workplace (AOHS, 2013).

Studies on Key Variables

Battery Technicians' Workplace Conditions and Safety Practices on Lead Poisoning

Literature does exist on workplace condition, and the workplace condition comprises of safety measures available in the work environment (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014). Workplace conditionscould be influenced by the following attributable experiences like: environment and facility available for safety practices, employer-employee communication, information on toxicity of lead pollutants, training on lead poisoning safety practices, self-protective attitude of the technicians and availability of the PPE (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014). Levesque, Arif, and Shen (2012) stated that the experience could explain 40.5% variation in the workplace condition. The workplace condition was significantly associated with technicians' cooperation with safety practices and not withdrawing from the use of the protective facilities (Kalahasthi et al., 2016).

The researchers in North Carolina, United States of America had employed cross-sectional approach to examine the association that exists between workplace and housing condition, and use of pesticide safety practices, and personal protective equipment among farm workers (Levesque et al., 2012). The study investigated the inconsistencies about the effects of the workplace condition and its influence on self-protective behavioral practices and use of PPE (Levesque et al., 2012). One hundred and eighty-seven (187) participants were enrolled in the study whichrevealed that improvement of workplace condition is crucial to increase the use of pesticide safety practices, and PPE at the workplace (Levesque et al., 2012). Levesque et al. (2012) found that availability of enough hot and cold water for bathing, and laundry resulted in likelihood to use pesticide safety practices (adjusted *OR*: 13.6, 95% CI: 1.4 – 135.4), and the farm workers that reported access to water to wash their hands while performing work were more likely to use PPE at the workplace (adjusted *OR*: 3.4, 95% CI: 1.3 – 9.2).

The independent variable: workplace condition relates positively to the quality of safety practices (Levesque et al., 2012). This study result is consistent with that of another study which indicated that availability of the safety facility and employer-employee communication are among the determinants of ideal safe workplace condition (Pogacean & Gurzau, 2014). The study was a cross-sectional design and questionnaire was used to collect data. The study could have suffered recall bias because the cause-effect of the relationship that exists between variables was not indicated.

Adebola (2014) investigated workplace conditions and compliance with safety practices in two locations of Pipeline and Products Marketing Company (PPMC) depot in Lagos, Nigeria. The researcher applied cross-sectional design and used quantitative methods for data collection from 142 participants to assess the workplace condition and compliance with the safety practices and use of PPE. A semi-structured questionnaire was used to gather information on workplace conditions while participant's compliance with the use of the safety equipment available was assessed in the studied depots. The data collected were analyzed with Epi-Info 2002 window version (3.5.1) and the association between workplace condition and utilization of PPE/compliance with safety practices was established (Adebola, 2014).

Findings showed that participants with positive workplace conditions are more likely to comply with safety practices and will not deviate from the use of the safety facilities available in their workplace (Adebola, 2014). The study detected an association between workplace conditions and the use of the PPE. The study used mixed-method, cases of drop out to follow-up among the participants was reported and this could have a negative influence on the results. The study finding was similar to the Ethiopia study that found workplace conditions to be statistically significantly associated with utilization of the personal protective equipment (Adelu et al., 2015).

Blood Lead Levels of Battery Technicians and Safety Practices on Lead Poisoning

In the past, the Occupation Safety and Health Administration permissible exposure limits of blood lead levels of occupationally exposed workers was put at 50.0μg/dL, while WHO put the permissible value at 40.0μg/dL, and the United States of America Center for Disease Control and Prevention stipulated permissible value of 40.0μg/dL (CDC, 2014; OSHA, 2013; WHO, 2014). Presently, the recent studies indicated that there is "no safe limit value" for lead exposure, and the value currently suggestedas case definition for elevated blood lead level (BLL) is $\leq$ 5.0μg/dL (ABLES/NIOSH/CDC, 2015; CDC Nationally Notifiable Condition, 2016; CSTE, 2015).

Were et al. (2014) examined factors that influence blood lead levels and safety practices among the lead battery workers that were exposed to lead pollutants in Kenya. The study was a prospective longitudinal design with 233 participants from six diverse industrial plants in Kenya. The blood lead level of the technicians was found to be associated with the type of the industrial plants and safety practices employed (Were et al., 2014). The mean blood lead levels of the workers in the six industrial plants were as follows:183.2 ± 53.6 μg/dL in battery recycling workers, 133.5 ± 39.6 μg/dL in battery technicians that work in the manufacturing plant, 126.2 ± 39.9 μg/dL in scrap metal welding workers, 76.3 ± 33.2 μg/dL in paint manufacturing workers, 27.3 ± 12.1 μg/dL in a leather manufacturing workers, and 5.5 ± 3.6 μg/dL in workers of a pharmaceutical plant (Were et al., 2014).

Furthermore, the researchers observed that factors like knowledge of the importance of the safety practices, years of experience and education level influences the adherence to safety practices at the workplace (Were et al., 2014). The importance of training and compliance with safety practices had been studied by Monney et al. (2014). The technicians training on safety practices is an important factor towards reducing high blood lead levels and fire incidence in the vehicle repairer artisan's workshop (Monney et al., 2014). The study revealed that psychosocial factors and emotional well-being of the vehicle repairer artisans were significantly associated with safety practices on lead poisoning at the workplaces (Monney et al., 2014).

The battery technician's blood lead levels could depend on his view and attitude towards safety practices at the workplace. A study on the feeling and view of lead occupationally exposed workers was conducted in Ghana with 100 participants (Monney et al., 2014). The study revealed that vehicle repairer artisans have a diverse opinion on the utilization of PPE; 27% of the participants reported the use of PPE at the workplace (27 of 100 participants; Monney et al., 2014). This study contrast with the results of the survey conducted on attitude towards safety practices among PPMC staff in Lagos, Nigeria (Adebola, 2014). According to Adebola (2014), a high proportion of the PPMC staff (120 of 142/85.2%) had a positive attitude towards protecting themselves from occupational hazards and accumulation of toxicity attributed to lead in petroleum products at the workplace.

Abdulsalam et al. (2015) argued that automobile technicians scarcely use PPE in Lagos, Nigeria for protection against lead exposure and the commonly used protective wear is overall cloth, if at all. Abdulsalam et al. (2015) opined that high blood lead levels of the automobile technicians could have a connection with safety practices at the workplace. The workplace environmental factors and circumstances could relate to and influence the rate of exposure to lead contaminants, the health status of the technicians, and to long-term effect on the well-being of the technicians (Adelu et al., 2015; Ahmad et al., 2014; Kalahasthi et al., 2016). In support of this argument, WHO (2014) stated that engagement in safety practices could reduce the adverse effect of lead exposure, and protect both physical and physiological well-being of the technicians from hazards associated with toxicity of lead. One of the pathways through which battery technicians'cooperation with safety practices could influence blood lead level is their readiness to adhere to theuse of PPE which offers a better chance of reducing the rate of exposure to lead poisoning at the workplace (Kalahasthi et al., 2016).

A retrospective study was conducted among children below 5years of age in Flint City, Michigan, United State of America to determine the Elevated Blood Lead levels (EBLL) associated with drinking water crisis: A spatial analysis of risk and public health response (Hanna-Attisha, LaChance, Sadler, & Schnepp, 2016). According to Hanna-Attisha et al. (2016), the study participants were children living in the Flint City (*n*=1473; pre =736; post =737) that received water from the city water system compared with (*n*=2202; pre =1210; post= 992) children living outside the Flint City where the water source was unchanged. The pre-time period was between January1, 2013, to September 15, 2013 (time before the water source change) and the post-time period was January 1, 2015, to September 15, 2015 (time after the water source change).

The study findings revealed a statistically significant increase in the proportion of Flint children with Elevated Blood Lead Level (EBLL) from the time the water source was changed (Hanna-Attisha et al., 2016). It was determined that 2.4% (17of 736) of the children in Flint City had an EBLL in the pre-period while 4.9% (36 of 737) of the children in Flint City had an EBLL ($p < 0.05$) in the post-period (Hanna-Attisha et al., 2016). Hannah-Attisha et al. (2016) stated that when compared the EBLL of the Flint City children who drank lead contaminated water to the EBLL of the children outside of the Flint City who drank uncontaminated water, the change in Elevated Blood Lead Levels (EBLL) was significant (0.7% to 1.2%; $p < 0.05$). The increase in the percentage of the EBLL of the children living in the Flint City from 4.0% to 10.6% ($p < 0.05$) was due to lack of proper safety practices and the water source was contaminated with lead pollutants.

Battery Technicians' Education and Safety Practices on Lead Poisoning

Study that relates battery technician's education with safety practices and utilization of personal protective equipment is scarce though education could be one the factors that determine health but the provision of safety facilities could positively influence self-protective safety behavioral practices (Were et al., 2014). Studies conducted in Kenya, Ethiopia and Nigeriahad shown that there was statistically significant association between technician's education attainment, safety practices, utilization of safety facilities and PPE at the workplaces(Abdulsalam et al., 2015; Adela et al., 2012; Were et al., 2014).

In a cross-sectional study on occupational health and safety practices among 100 vehicle repairer artisans in an urban area of Ghana, the finding revealed that education level of the artisans was not statistically significant with the participant's safety practices

(Monney et al., 2014). This study finding was in contrastto a cross-sectional study conducted among 142 participants on knowledge, attitude, and compliance with occupational health and safety practices among Pipelines Products and Marketing Company (PPMC) staff in Lagos (Adebola, 2014). The study shows that 87.4% (118 of 142) of the participants with qualification above secondary school education had good occupational safety practices; a high level of education could have influence awareness and improve compliance with occupational safety at the workplace (Adebola, 2014).

Battery Technicians' Knowledge of the Importance of Safety Practices and Utilization of Personal Protective Equipment (PPE) at the Workplace

Battery technicians' knowledge of the importance of safety practices and utilization of PPE at the workplace has not been studied. On the other hand, researchers have demonstrated an association between knowledge of safety practices and improved self-protective behavior at the workplace (Kalahasthi et al., 2016; Kim et al., 2014). Kim et al. (2014) argued that cognitive understanding and appreciation of the importance of self-protective safety behavioral practices at the workplace could predispose compliance with the use of PPE. A non-experimental cross-sectional study design was conducted to investigate workplace self-protective behavior of 320 staff nurses of two university hospital located in Incheon and Kyungi province of South Korean (Kim et al., 2014). The findings of the study revealed that 41.2% (132 of 320) of the participants adhered to positive self-protective behavior at the workplace (Kim et al., 2014). The compliance could be associated with in-depth knowledge of the importance of safety practices and the participants' willingness to overcome safety barrier and occupational hazards at the workplace (Kim et al., 2014).

Similarly, Adebola (2014) found that a high proportion of the studied participants 68.3% (97 of 142) of the PPMC staff were aware of the occupational hazards and control practices at their workplace,and this was statistically significant with the educational level of the participants in which 95% (135 of 142) had postsecondary education as a result of the company policy on minimum education requirement at the entry point and this could have influenced their knowledge of safety practices (Adebola, 2014). Abdulsalam et al. (2015) study findings contrast the findings of these studies above on knowledge, though the researchers found 92% of the participants studied to be awared of the toxicity of lead poisoning but argued that high proportion of the automobile technicians scarcely use safety equipment and if at all they use it, it is the overall cloth that they do wear while atthe workplace. The implication of this study is that technicians occupationally exposed to lead contaminants could be aware of the toxicity of the lead, but this awareness does not necessarily mean that they have knowledge of the importance of safety practices on lead poisoning at the workplace and the related long-term health impacts of exposure.

Battery Technicians' Perceived Risk and Utilization of PPE at the Workplace

The study on perceived risk and utilization of PPE is scarce as researchers have not conducted study on the awareness of the dangers associated with lead poisoning at the workplace of battery technicians. The researchers argued that high proportion of automobile technicians studied scarcely use PPE at the workplace (Abdulsalam et al., 2015). This study implication is that the battery technicians who were occupationally exposed to lead contaminants were not aware of the associated risk of lead poisoning, and this lack of awareness of the danger associated with lead poisoning contributed to persistent exposure to the toxicity.

Similarly, battery technicians' rate of utilization of PPE at the workplace has not been studied. On the other hand, the researchers have demonstrated that an association exists between perceived risk and improved self-protective behavior at the workplace (Kalahasthi et al., 2016; Kim et al., 2014). Kim et al. (2014) stated that cognitive understanding and appreciation of risk; that is the threats associated with the workplace hazard could predispose compliance with the utilization of PPE. In a non-experimental, cross-sectional study conducted to investigate 320 staff nurses of two university hospital in South Korean on their response to workplace threat as a result of perceived risk (Kim et al., 2014).

The findings of the study revealed that 60.2% (232 of 320) of the participants who adhered to utilization of safety measures at the workplacewere doing so as a result of their knowledge of the risk associated with the hazards of their job (Kim et al., 2014). This study implication is that workers who have knowledge of the dangers (hazards) associated with their work are likely to comply with the use of the personal safety equipment. The reason for the compliancewith the use of safety measures is to overcome barrier and occupational hazards at the workplace. Furthermore, if battery technicians received information concerning the associated health effect of lead poisoning during safety training sessions they could have acquired useful information on the threats of lead toxicity.

Adela et al. (2012) argued that lack of awareness of the non-specific symptom of lead poisoning is a problem as battery repairers could not associate the occurrence of wrist drop, tingling, numbness in finger and hands, nausea, abdominal discomfort and reduced libido to the effect of lead poisoning. In the study conducted in Ethiopia, the proportion of individual affected by the non-specific symptoms were those technicians with BLL of 16.0 to 20.0µg/dL and above which could be a clear indication of the negative health impact of BLL as low as 10.0µg/dL (Adela et al., 2012).

Battery Technicians' Years of Experience and Safety Practices on Lead Poisoning

The study that established an association that exist between battery technicians' years of experience and safety practices on lead poisoning at the workplace was searched extensively but could not be found. Most of the literature on blood lead levels studied does not statistically test the association that exists between years of experience and its influence on safety practice at the workplace. In a cross-sectional study on occupational health and safety practices among 100 vehicle repairer artisans in an urban area of Ghana, the finding revealed that years of experience on the job does not statistically significant with the participant's safety practices (Monney et al., 2014). Furthermore, the majority of the researchers do not always put years of experience as one of the demographic characteristics of the study.

Battery Technicians' Age and Safety Practices on Lead Poisoning

The search for literature on the study that finds an association between battery technician age and safety practices on lead poisoning at the workplace yielded no result. However, the clinical psychologists have argued that age is a personal factor that could influence thought and impact self-protective behavioral practices (Kim et al., 2014). Most of the researchers that conducted study on blood lead levels among technicians that were occupationally exposed to lead poisoning do not statistically tested the relationship that exists between the automobile technician's age and the blood lead levels, instead they all stated the mean age of the participants studied (Singh et al., 2013; Shaik et al., 2014).

Critique of Methods

Investigators had applied population based prospective cohort study design to investigate factors relating to safety practices on occupational lead exposure and association with selected cancers (Liao et al., 2016). The study data were gathered through assessment of records provided by the community health office, public health records, and national occupational health survey. In this study, 73,363 female resident aged 40-70 years were followed between 1996 and 2000 while 61, 466 men of the same age range were observed between 2002 and 2006 for safety practices on lead exposure at the workplaces (Liao et al., 2016). The study revealed that training on safety practices, availability of safety facility, and safety conscious work environment impact the safety practices at the workplace (Liao et al., 2016). This study results could have been influenced by the loss of participants to follow-up (maturation threat). Although the target population was large but the studied participant's may not give the true representation of the people that were occupationally exposed to lead poisoning at the workplace, since the selected facilities were mainly located in Shanghai, China. The above reason will affect the generalizability of the results.

Rentschler et al. (2011) used historical cohort design to evaluate factors that influence the long-term elimination of lead from plasma, and whole blood after exposure to lead poisoning. The sources of the data were from physicians' record for the five cases of clinical lead poisoning studied. Four nonoccupational and one occupational patient were assessed. The researcher followed the participants for 21 to 316 months, and their duration of exposure to lead poisoning was from one month to twelve years. The researchers observed that availability of safety facility and socioeconomic status of the participants was associated with the safety practices at the workplace (Rentschler et al., 2011). The retrospective administrative sources of data could affect the validity of the study because the ability of the investigators to record accurate and complete information may not be ascertained. Furthermore, the subjects that were supposed to be studied by the investigator but did not use the clinic facility where the study was conducted may have been excluded from the study; hence this will affect the generalizability of the findings.

In Ghana, researchers examined the effect of technician's belief, delay or noncompliance with safety practices at the workplace (Monney et al., 2014). It was revealed that lack of faith in the preventive safety measures was statistically significantly associated with the delay or noncompliance with safety practices (Monney et al., 2014).

The number of participants recruited for the study (100 participants) is small and may not give true representation of the general population. Furthermore, the survey was done with the administration of questionnaire at the workplace and the statistical test used for the data analysis was chi-square (X^2) test of difference, hence there could be possibility of recall bias.

Ajayi et al. (2014) and California Department of Public Health (2014) used data from the health survey conducted at the national level to study factors associated with blood lead levels and safety practices in Nigeria and the United State of America respectively. The two studies revealed that safety practices on lead poisoning were statistically significantly associated with education attainment despite the socioeconomic differences between the two countries. Demographic Health Survey (DHS) may lack accurate and complete demographic information necessary for the study. Secondly, a nationwide demographic and health survey in developing country like Nigeria could suffer administrative inaccuracy, and that could negatively influence the survey outcome.

The cross-sectional design is popularly used by the researchers who studied blood lead levels and safety practices at the workplaces. Abdulsalam et al. (2015) and Kalahasthi et al. (2016) used cross-sectional approach to conduct a descriptive survey on blood lead levels at the workplaces of automobile technicians in Nigeria and India respectively. Dongre et al. (2011) employed cross-sectional survey design and adopted systematic sampling procedures in the selection of the participants; the researcher also determined the sample size before collection of data for the study. Conversely, Rentschler et al. (2011) did not state the standards used to ensure the validity and reliability of the instrument, and whether the availability of safety facilities impacts the safety practices at the workplace. The workplace conditions and training support on safety equipment usage could influence the safety practices status of the participants (Kalahasthi et al., 2016; Monneyet al., 2014). Lack of information on safety facilities and usage could negatively influence compliance with safety practices at the workplace (Kalahasthi et al., 2016).

In this study conducted on safety practices on lead poisoning among battery technicians, I used a quantitative method; cross-sectional survey design with the administration of questionnaires to collect data. The findings of this study could fill the gap in knowledge as it focused on safety practices, workplace condition, and the rate of utilization of PPE. Furthermore, I compared the safety practices of battery technicians in the organized and roadside settings. I determined the sample size based on the statistical model used, and multistage and systematic random sampling technique was used to select the participants examined. Finally, the knowledge of the importance of safety practices and likely effect of lead exposure and associated health implications was assessed. Abdulsalam et al. (2015) and Ahmad (2014) supported the methodology of this present study. Both studies had used quantitative, cross-sectional survey with random sampling technique to select the participants, determined the sample sizes and the questionnaire was the instrument used to collect data.

According to Creswell (2009), the cross-sectional survey design could suffer from inaccuracy of denominator especially when official population censuses are not available as the case in the developing country like Nigeria but this did not affect this study design. This study could only suffer bias probably due to the inability of the battery technicians to recall information on safety practices correctlyduring data collection (Pogacean & Gurzau, 2014). In conclusion, the multivariate logistic regressionsand univariate statistical model used for the analysis of data collected in this study could improve the limitation attributed to the cross-sectional survey methodology (Cresswell, 2009).

Summary

The gain attributed to safety practices on lead poisoning could have been eluding battery technicians in Lagos, Nigeria, due to delay or noncompliance with standard safety practices, and lack of enforcement program at the workplaces. In consequence, this could affect the socioeconomic status of the battery technicians and result in long-term adverse health impacts as a result of lead intoxication. Blood lead levels of the battery technician measures the extent to which safety practices is being adhered to at the workplaces, and is the relevant index in the lead safety program evaluation. Occupational lead poisoning is one of the most known occupational diseases that have been identified in the earliest time. The acute effects of lead poisoning have been recognized in the manual workers and slaves, but scarcely been considered at that early period.

The first clear description of lead toxicity was dated back to the second century BC when a physician named Nicander identified the acute effects (colic pain) associated with high dose exposure to lead. The first preventive strategies in factories were introduced in the mid 20th century with the introduction, and use of exhaust ventilation, personal protective equipment, wet dusty process and the chelating agent that was introduced to provide therapeutic tool against lead poisoning. In the year 2000, the United State government mandated Occupational Safety and Health Administration agency (OSHA) to detect and provide safety measures on noxious agents such as lead poisoning in both living and working environment which is the main focus of this study.

Investigators have studied safety practices at the workplaces in the community settings using; primary data collected directly from survey, and secondary data collected during initiative program organized locally and nationally by stakeholders on lead poisoning. The independent variables that could impact safety practices status are: workplace conditions, knowledge of the importance of the safety practices, and benefit of the safety practices. Occupational characteristics like location of the workshop setting, the level of occupational infrastructure development, and safety facilities were among the variables studied. Finally, variables associated with features of the system were considered and these include: availability of the safety facilities, control measures in place at lead occupation workplace (administrative control/engineering control/PPE), belief, and attitude of the technicians.

This study intended to fill the knowledge gap identified in literature as I focused on safety practices and utilization of PPE at the workplace of battery technicians. The quantitative method, cross-sectional research design was employed to test and describe the association that exists between safety practices and workplace condition, blood lead levels, utilization of PPE. I compared the safety practices of battery technicians in the organized and roadside settings. Finally, I used the study to examine an association that exists between safety practices and education attainment of the battery technicians. In chapter 3, the quantitative research design used to test an association that exists between variables of interest in the study was stated. The sample size determination and statistical analysis and instrument used for data collection were described in detail in this chapter. Chapter 4 presents the analysis of the data while chapter 5 present the discussion, recommendations, conclusions, and implications of the findings of the study for positive social change of the participants and the community.

Chapter 3: Research Method

Introduction

This study was a quantitative, cross-sectional survey design, and primary data were collected from the target population. The data gathered from the survey ofthe safety practices on lead poisoning among battery technicians were used to answer the research questions. The study was conducted in Lagos, Nigeria, West Africa. Multistage sampling method was used to delimit the population size of the two selected local government council areas studied. The systematic sampling technique was used to select the participants. In this study, an association that exists among safety practices, workplace conditions and blood lead levels was examined. I discovered that an association exists between safety practices and education attainment and knowledge of the importance of safety practices.

Furthermore, the safety practice of battery charging technicians in the organized and roadside settings was compared. A test-retest pilot study was conducted at an interval of 2 weeks to ascertain the validity and reliability of the self-developed questionnaire before it was used for the main study. The questionnaires with close-ended questions were administered to the participants to gather the required information for the study. The data collection was carried out for 6 weeks, and the target population was battery technicians who were adult aged 18 years and above, with their workshops located in the organized and roadside setting of the two selected local government areas of Lagos, Nigeria. The data collected were collated, and error on the field was corrected before the input of the data into a computer system; analysis was done with SPSS software version

21. Confidentiality was maintained to protect the participants' data during collection, collation, analysis, and throughout the study.

Research Design and Rationale

Research Design

This study wasa quantitative, cross-sectional design and it tested the stated hypotheses using the variables of interest and addressed the research questions. The cross-sectional design naturally measures and records the attribute of variables in the study (Creswell, 2009). The cross-sectional survey design is useful for the gathering of data from dispersed geographical districts and could be conducted timely with minimal cost; the study findings could also be generalized to the entire population (Creswell, 2009). Primary data were collected with self-administered questionnaires I developed. The instrument was assessed by the dissertation supervisory committee members and two other scholars who are specialists in the field of public health and occupational safety and health.

In this study, I examined factors related to the safety practices status of battery technicians. Questionnaires were used to collect information on the workplace conditions, self-protective behavioral practices, and rate of utilization of PPE. The workplace conditions measured the safety practices on lead poisoning; the rate of utilization of the PPE and the blood lead levels were reported by the battery technicians in the questionnaire. The availability and frequency of usage of PPE were used to examine the safety practice status of the battery technicians. Furthermore, the blood levels of the battery technicians were compared with the acceptable reference value ($\leq 0.5\mu g/dL$)

suggested by the National Institute of Occupational Health and safety for blood lead level of lead occupationally exposed workers.

Rationale for Choosing the Design

The quantitative method, cross-sectional survey design was preferred for this study due to the large population selected for the survey in Lagos, Nigeria and the dispersed nature of the subunits that were involved. The designwas also executed with minimal cost and time, and the results could be generalized to the entire population. The cross-sectional approach determined an association that exists between the dependent and independent variables through the use of the appropriate statistical procedure.

Methodology

Target Population

The target population for this study was N =300 adults aged 18 years and above, but the number of subjects who participated in this study was N=293. The breakdown of the total number of subjects who participated in each setting of the survey was n=148 for battery charging technicians in the organized setting and n=145 for battery charging technicians in the roadside setting.

Study Setting

I conducted this study in Lagos, Nigeria, and the settings of the survey were two local government council areas (Ikeja and Agege) out of the 20 local government councils in Lagos state, Nigeria. The population of Lagos state is about 20 million people, and 0.2% of the population consists of battery technicians who registered with their association (Opeifa, 2013). The population of the two selected local government council areas for this study combined is around 4 million. Lagos state is situated on longitude 3-degree 24 inches east of the Greenwich meridian and latitude 6-degree 27 inches north of the Equator. The state is located in the southwestern region of Nigeria and is a megacity with the largest and most extensive road networks in West Africa; it is also the commercial capital of Nigeria where most of the nation's wealth and economic activities are concentrated.

The Lagos state ministry of transport stated that the state has a total road network of 5000 Km, and the road network density is 0.6 Km per 1,000 population with over 1 million vehicles plying them on a daily basis, causing the highest vehicular density of over 200 vehicles/Km against national average of 11 vehicles/Km (Opeifa, 2013). This situation leads to regular vehicular congestion on the road with pressure on motor batteries due to the longer time spent in the traffic jams. The state have mechanic villages where battery chargers work (organized setting), and others have their workshop along the road (roadside setting). For the purpose of this study, only battery technicians in the two selected local government council areas were considered. Each selected local government council areas was divided into zones, then into districts, and then into wards, with the specified number of battery technicians located there.

Sampling and Sampling Procedures

Determining Sample Size

The sample size analysis for this study was done to determine the appropriate number of subjects that could give an accurate representation of the participants studied. I used chi-square (X^2) to assess the significant association that exists between the categorical and binary variables, and multiple logistic regressions were used to measure the odds ratio that is the likelihood that a significant association exists between the variables of the studied population. Peduzzi, Concato, Kemper, Holford, and Feinstein (1996) suggested the guideline for a minimum number of cases to be included in a study using a logistic regression statistical model for analysis, and the formula of those researchers was adapted to calculate the sample size for this study. Thus,

$N = 10\ K/p$

N= is the sample size for the study

k= is the number of covariates (the number of independent variables)

p = is the smallest proportion of the negative or positive cases in the population, and it was assumed that the proportion of positive cases in the population is 0.20 (20%). Then, the minimum number of cases required for this study was calculated like this:

$$N = \frac{10 \text{ x } 5}{0.20}$$

$N = 250$

I intended to find the proportion of battery technicians' who currently practice safety on lead poisoning at the workplace (that is safety practice status). Then, I determined the appropriate number of the subjects (sample size) that could give accurate representation of the participants studied for economic, ethical and scientific reasons. In this study, I have five predictors (workplace conditions, blood lead levels, education level, knowledge of the importance of safety practices, and perceived risk of lead poisoning), and the dependent variable was the safety practice status of the battery technicians on lead poisoning within a 2 year limit due to scarce literature on the safety practices on lead poisoning.

To ensure a 95% confidence interval estimate of the proportion of battery technicians who practice safety on lead poisoning at the workplace is within 5% of the true proportion. A sample size of 300 subjects was proposed for this study to involve a larger population. Hence, 300 questionnaires were printed but finally a sample frame of 293 which was above the calculated sample size of N=250 were studied. The reasons for increasing the sample size was to guide against the threats to external validity, to increase the statistical power, to ensure accuracy, reliability, and protection of the ethical integrity of the survey so as to be able to generalize the findings of the study.

The statistical power of a study is critical. This study statistical power was .90. The larger the sample size used N=293 >N=250, the greater the statistical power of the study if a good research design and correct sampling techniques is used. Smaller samples are less likely to give good representation of the population characteristics. In this study, given the calculated effect size of .78, it was necessary that I increased the sample size from N=250 of power .80, to N=293 of power .90 and or N=396 of power .99. These increase represent an 18 to 70 percent increase over the number of subjects calculated earlier N=250 so as to increase the statistical power of the study.

Sampling Procedure and Strategy

Rudestam and Newton (2015) defined sampling as a strategy used to select a subset of the population being studied. In this study, the sampling procedure that I used to choose the final participants without having to measure the entire population was a multistage sampling method and systematic sampling techniques. The rationale for choosing this sampling method is that it ensured a true representation of the target population. The two selected local government council areas in Lagos were divided into tertiary units (5 geographical zones) first and this comprised of (North, South, East, West, and Central geographic zones). The tertiary units were divided into secondary units (10 district areas); the district's areas were further delimited into 100 wards each that make up the primary units (individual levels).

Upon completion of the division of the large population, the systematic sampling technique was used at the primary units (individual level) to sample the target population (adult battery technicians). According to Creswell (2009), the systematic sampling technique carries out the selection of samples equitably by spreading the selection. The sampling interval for this study was calculated by dividing the total population of the battery technicians workshops in the 5 geographical zones of the two selected local government council areas with the number of the workshops to be sampled using the formula;

$$K = \frac{N}{n}$$

K is the sample interval.

N is the total population of workshops in the 5 geographical zones of the 2 selected local government councils.

n is the number of workshops sampled in the study areas.

$$K = \frac{N = 5000 \text{ (Total Population of Workshops)}}{n = 300 \text{ (No of Workshops sampled)}}$$

$K = 16.666666667$

The population was not exactly divisible; therefore, the random sampling starting point used for the study was selected as anoninteger between 0 and 16.666 (inclusive on endpoint only to ensure every workshop has an equal chance of being selected). The sample interval (16.666) was rounded up to the next integer, which is17. I assumed that the starting point for the systematic random sampling was 3.6; then, I selected the workshops at an interval of 4, 17, 30, 43, and 56. The interval value was added at every point in the population until the sample frame that corresponded with the sample population was selected. I continued the processes until the 100 wards with 10 units in each of the 5 geographical zones were sampled.

Procedures for Recruitment, Participation, and Data Collection (Primary Data)

Procedure for recruitment: in this study, to choose the workshops where the battery technicians were recruited, each ward with battery technician workshops was subdivided into quadrants. For each of the quadrants, a systematic sampling technique was used to detect the direction of the workshops sampled. Using this approach improves the validity of the sampled frame (Simoes et al., 2011). The complete listing of all the workshops in the selected direction was adjusted for in the study. The direction was the starting point for the first workshop selected, and the two eligible workshops were chosen. I continued the procedure repeatedly in the entire quadrant selected, as suggested by previous researchers (Abdulsalam et al., 2015). Finally, I used the systematic sampling technique to select adult battery technicians who participated in this study as explained above in the sampling procedure. This is the method that I used to recruit the eligible battery technicians aged18 years and above.

Participants' Eligibility Criteria

The inclusion eligibility criteria for the participants were as follows: Battery technicians must be 18 years of age and above. The battery technicians, who have their workshop located in either mechanics village (organized setting) or at the roadside setting along the streets in Ikeja and Agege local government council areas of Lagos state, were eligible to participate in this safety practices survey. These criteria ensured equal opportunity was given to include all battery technicians who were eligible to take part in the study. The medium of communication for the participants was English language, which is an official language in Nigeria.

Participants' Exclusion Criteria

The exclusion criteria for the participants included battery technicians' who have their workshop located outside mechanics village (organized setting) and outside the roadside setting along the streets in Ikeja and Agege local government council areas of Lagos state. Moreover, battery technicians on visitation to the workshops located in the study setting were excluded. Battery technicians who were unable to communicate in English language, which is an official language, were also excluded from the study.

Data Collection (Primary Data)

The participants were invited and requested to complete consent form freely before filling out the questionnaire. Information was collected from the participants (primary data) with the structured questionnaire, and the nature of the information obtained included the demographic and occupational characteristics of the subjects like the age, marital status, income, year of experience, level of education, and location of the workshop. In the subsequent sections, the questions cover each hypothesis like workplace condition, blood lead levels, education attainment, the frequency of usage of PPE, and knowledge of the importance of safety practices on lead poisoning at the workplace, associated risk factors, and health impacts of lead intoxication.

Pilot Study

A pilot study is defined as a small version of a full-scale study or feasibility study in preparation for the main study (Creswell, 2009). Once a researcher or groups of researchers have a clear vision of the research topic, formulated research questions, identify research method, and techniques, the next step is to carry out a pilot study for the assessment of the study procedures to avoid mistake during the large-scale study (Rudestam& Newton, 2015). The purpose of this pilot study was mainly to try out the research techniques and methods, and to test the questionnaire on a group of battery technicians outside and far away from the study settings. During the process of the pilot study, all the five sections of the questionnaire, demographic and occupational characteristics, workplace conditions, safety practices, utilization of PPE, and knowledge of lead poisoning, were assessed. The feedback on all the items were analyzed, and it was ascertained that the research method and technique were appropriate and that the questionnaire measured what it intended to measure before proceeding to the large-scale study.

The pilot study was essential to prevent waste of energy, time and money. The values of this pilot study were stated below:

1. To detect any possible flaws in measurement procedure like instruction in the questions and also to detect the possible error in the operationalization of the independent variables. Two different measurement procedures were carried out on the research groups, the first measurement test was to gain information and the second measurement was a re-test that was used to clear out practical difficulties like duplication of information in the questionnaire.
2. To identify ambiguous or unclear items in the questionnaire; the necessary action was taken and those items identified were clear out, time limit spent in responding to the questionnaire was also determined and the clarity of instructions ascertained.
3. The pilot study was valuable as it discovered the discomfort experienced concerning the content or wording of the items in the questionnaire based on the non-verbal behavior of the battery technicians that participated in the pilot study. This feedback was noted and implemented on the questionnaire.
4. The pilot study was valuable as it indicated where research protocol was not followed.

5. With the pilot study, it was detected that the proposed methods and instrument were appropriate and suitable for the study.
6. Finally, the pilot study established and affirmed that the procedures employed in the survey would identify what the research intends to measure without any flaws.

This pilot study goal was achieved because it established that the arrangement was appropriate and that no adverse influenceon the success of the research procedures and all practicalities related to the instrument designed for measurement in the research applied to the potential outcome of the study.

Intervention

The intervention gave the detailed overview of the steps that was applied to the pilot group and is discussed as follows in summary form. The intervention program for this pilot study was carried out on battery technicians in a location outside and far away from research settings. The location of the identified members of the intervention group was Ibadan, Oyo state, Nigeria. The group of the battery technicians that participated in the pilot study was introduced into the pilot study program, and this step involved a lot of talking to clear issues of why they were taking part in the pilot study. The process of filling the questionnaire was explained to the pilot group from beginning to the end. The rule to follow was discussed, and each member of the pilot group received a questionnaire to complete after completing the consent form freely for the pilot study.

The members of the intervention group through which the research methods and assessment of the questionnaire was tested was 50 subjects that had similar characteristics with the research participants. Upon completion of the questionnaire, the pilot program was terminated for analysis of the questionnaires filled by the pilot group. Observations were made and a note was taken during contact session, and the questionnaire filled by the pilot group members was analyzed for the decision taking. The outcome of the analysis of the piloted questionnaire was used to adapt the final questionnaire that was more effective in reaching the aim of the study. To determine the validity and reliability of the instrument a test re-test method was adopted in which the questionnaires were administered twice to the same set of participants at interval of 2 weeks. The outcome of the pilot study on techniques, methods, instrument and questionnaire was reviewed and validated before usage in the large-scale research project.

The outcome of the intervention program of the pilot study was divided into two categories: practical considerations and assessment of instrument, and questionnaire.

Practical Considerations: the practical consideration that needed attention in this pilot study were attended to and it include; interpretation of the questions in the questionnaires, time limit to fill the questionnaire, the willingness of the battery technicians to participate in the study, rushing of the process and keeping the process smooth so that longer time was not spent than planned time for the research study. Finally, the cultural background of the battery technicians was also considered in the pilot study.

Assessment of the instrument and questionnaire: the outcome of the evaluation of the instrument (questionnaire) was used to confirm the appropriateness of the methods and the procedures. Also, the ambiguous or unclear items identified in the questionnaire were cleared out of the items. Any vague instruction in the content or wording of the question was restructured to serve the research purpose and the clarity of instructions.

The final instrument for this study was reviewed and validated by three scholars, two public health experts from academic and one expert in field practice. The expert's examined the questions by:

- Determining whether the questions were clear, conciseand unbiased.
- Determining whether the questions were directed towards the research purpose and that it would answers the research questions.
- Determining whether the responses to the questions were relevant and provides all inclusive.

Any difference noted was reconciled with the battery technicians' opinions before final questionnaires were produced for the large scale research study. The scores were assigned to the responses of the participants in the questionnaires completed. The reliability of the test-retest questionnaires was determined with the value of person's coefficient of correlation (*r*). The value of *r* was assessed for the good of fit and the value was 0.70, then it was considered good. I determined the internal consistency of the questionnaire, that is how well the questions synchronized together by computing Cronbach's Alpha reliability coefficient. The value of the Cronbach's Alpha was 0.8, and it was considered that the questionnaire reliability is good.

Instrumentation and Operationalization of Constructs

Type and Name of Survey Instrument

For this present study, secondary data was not available to answer the research questions and for this reason; I administered questionnairesto collect the data. The search for the existing suitable standard instrument for this study yielded none, so I developed a structured questionnaire with close-ended questions from reviewed literature and epidemiological study of the causes of lead poisoning among occupationally exposed workers. Three specialists in the field of occupational medicine and safety assessed the questionnaire. Questions were prepared to test all areas of the study and the instrument divided into six sections based on the hypotheses to be tested in the survey. Refer to Appendix A to locate the structured questionnaire.

Administration of the Instrument

In this study, I administered the paper based questionnaires to collect the primary data directly and daily for 6 weeks. The consent of each participant was secured freely before requesting completion of the questionnaire.

Location of Data

The questionnaires completed by the participants were kept in my custody securely in a locked cabinet, and they would be secured for five years after which they would be destroyed by me. Confidentiality and security of the completed questionnaires were ensured during the data gathering process and throughout every stage of the study. Furthermore, the collated data was storedsecurely in a password protected computer system thereby preventing unauthorized access to the data.

How Scores Were Calculated

The questions in the instrument were close-ended questions without multiple choice answers. The subject rating was “YES” for the positive response and “NO” for the negative response. The questions on practice section were designed to assess compliance with safety procedures at the workplace and the rate of usage of personal protective equipment on lead poisoning. The response was scaled from 0-1 using Guttman scale of response. The response was coded in which “1” stand for a correct answers while “0” stand for the wrong answer. The method of scoring adopted for the level of safety practices on lead poisoning was that participants who scored 9 points and above ($\geq$ 70%) were rated good practice while participants who scored $<$ 6 points ($<$50%) out of the 13 questions on safety practices were rated poor.

In this study, for questions on knowledge section; the scoring method and categorization system on the level of knowledge was adopted in which participants who scored $<$ 3 points ($<$50%) out of the 6 questions on knowledge section were rated to have poor knowledge of lead poisoning safety and participants that scores 5 points and above ($\geq$ 70%) were rated to have good knowledge of lead poisoning safety practices. The questions on the workplace condition and personal protective equipment were analyzed based on the response of the battery technicians to questions in these sections with the option of (YES/NO).

Assessing Validity and Reliability of the Instrument

I tested the validity and reliability of the instrument for this study, with the aim of determining the empirical, face, content and construct validity of the questionnaire. I used pilot study for the process and it established the ease of the comprehension of the questions, effectiveness in providing information, and the degree to which different individuals understood the questions. The instrument was also checked for reliability that is how well the questions synchronized together. Cronbach's Alpha analysis was run on all the questionsin the questionnaire. A good internal consistency of the items in the questionnaire was indicated by high value (0.8) of Cronbach's Alpha coefficient. The result confirmed the reliability of the instrument as there was a good internal consistency among the questions in the questionnaire used for this study.

Manipulation of Variables

Manipulation of Independent Variables

The independent variables in this study were technician's workplace condition, technician's blood lead levels, technicians' education level, technician's knowledge of the importance of safety practices on lead poisoning, and perceived risk of lead poisoning. Data was collected on these variables thus:

Workplace conditions: is the availability of safety items that would protect battery technicians against lead exposure within the workplace environment and these include; hand soap, single use towel, drinking water, cups, water to wash hand at the workplace, bathroom to shower after work, training on safety practices, washing water separated from drinking water, information about lead poisoning safety measures display, and boss talking of safety measures and practice at workplace. Questions number 08 to 21 was used to measure the workplace conditions. Seven questions asked about safety facilities available at battery technician's workplace; five about contact with lead during work while two questions asked about control available in the workshops. Levesque et al. (2012) adapted a similar measurement to assess the workplace conditions.

Battery technician's education level: is the level of formal education attained by battery technician. Question number 4 in the questionnaire was used to measure the education level attained by the technicians.

*Battery technician's knowledge of the importance of Lead poisoning safety practice:*is the understanding of the battery technicians about lead poisoning safety practices. Question 39 to 44 was used to measure the knowledge of the technicians on lead poisoning safety practices. These questions tested technicians understanding about lead poisoning at the workplace. The responses were either YES or No.

Blood Lead Levels (BLLs) *of battery technicians*: is the biomarker that was used to determine the blood lead toxic exposure and the risk of lead poisoning. Less than 5.0µg/dL (0 – 4.9µg/dL) was not considered lead poisoning but 5.0µg/dL and above was considered elevated blood lead level (EBLL) (NIOSH, 2015). Question number 44 was used to measure the battery technician's blood lead levels. This question asked battery technicians about the current value of their blood lead level. The question was close-ended and it asked battery technicians to tick the value of their blood lead level in the past six months.

Battery technician's perceived risk: is the perception of battery technicians on the danger associated with lead poisoning at the workplace. Question number 34 in the questionnaire was used to measure the perception of the risk related to lead poisoning.

Dependent Variables

This study has two dependent variables: the first dependent variable was the safety practices status of the battery technicians, while the second dependent variable was the utilization of the personal protective equipment (PPE).

Safety practices status: is the procedure adopted by battery technicians for carrying out specific tasks that ensure worker's exposure to lead at the workplace is controlled in a safe manner. Questions number 23- 34 was used to measure the safety practices status of the battery technicians through the recall of safety practices on lead poisoning at the workplace.

Utilization of Personal Protective Equipment at the workplace (PPE): these are personal safety tools that protect battery technicians at the workplaces against lead exposure and these includes; face mask, eye goggles, the respirator mask, protective clothing, and safety helmets, etc. Question 35-38 was used to measure the rate of utilization of the personal protective equipment available at the workplace of battery technicians.

Covariates Variables

The variables that covariate on the first dependent variable of this study; the safety practices status of the technicians include technician’s income, education level, marital status, availability of safety facilities, knowledge ofthe importance of safety practices on lead poisoning, and location of the workshop (organized or roadside setting). All these covariates were measured as follows:

Battery technician’s age: The calculated time in years that the battery technicians have lived on earth since birth. Question number 1 in the questionnaire was used to measure the aged of the participants

Battery technician’s education level: is the level of formal education attained by battery technician. Question number 4 in the questionnaire was used to measure the education level attained by the technicians.

Technician’s income: Question 6 was used to measure technician’s income based on the information against their response, and the range of the income was per month.

Marital status: Question 3 was used to measure the marital status of the technicians by the information given on the question.

Availability of safety facilities: Questions 35-38 was used to measure the availability of safety facilities in and around workplace environment of the battery technician’s.

The variables that were covariate for the secondarydependent variablethat is; the utilization of the personal protective equipment at the workplace include technician’s income, training received on usage of PPE, location of the technicians workshop, and availability of PPE at the workplace. All these covariates were measured as follows:

Training received by technicians on usage of PPE: Question 37 was used to measure the training received by technicians on theusage of personal protective equipment.

Availability of PPE at technician's workshop: Question 35 was used to measure the availability of PPE at workplaces of battery technicians, either in the organized or roadside setting.

Location of technician's workshop: Question 5 was used to measure the location of the technician's workshop whether it was located in the organized or roadside setting of the selected local government areas of this study.

Technician's education attainment is an independent variable as well as covariate variable respectively for the safety practices at the workplace, and the question used to measure the variable has been defined earlier in this session.

Data Analysis Plan

In the analysis of data, the first step I took was to correct errors during the field work and this was achieved through the screening of completed questionnaires manually for coding errors, eligibility of writing and completeness. All errors detected were corrected immediately before the onset of analysis with the computer. I imported the data intointo the computer. The variables were input into frequency table to check errors and list of command wereused to detect any irregularity in the entry. The dependent variables were categorized and classified as binary variables before entering of the data into SPSS software version 21 for statistical analysis. The frequency and descriptive statistics were used to present the data. The univariate statistical test was used to establishan association that exists between covariates and dependent variables. The alpha (α) level acceptable as significant was $p < 0.05$. Also, the multivariate logistic regressions analysis model was used to test independent variables of workplace conditions and perceived risk of lead poisoning and utilization of PPE at a statistical significant level of $p < 0.05$.

The odd ratio was adjusted for at 95% confidence interval (CI) with computation. The chi-square and logistic regressions analysis were the prefer statistical model of choice because the dependent variables were dichotomized into good safety practices at the workplace or poor safety practices at the workplace, utilization of PPE at the workplace or nonutilization of PPE at the workplace. The dependent variables in this study include safety practices and utilization of the personal protective equipment. While the workplace conditions blood lead level, technician's education level, technicians' knowledge of safety practices and perceived risk of lead poisoning were independent variables.

Statistical Analysis of Data

RQ1:Is there an association between the workplace condition of battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience)?

$H_0$1: There is no association between the workplace condition of battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

H_a1: There is an association between workplace condition of battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

The statistical modelused was multivariate logistic regressions statistical analysis, it established an association that exists between workplace condition and safety practices after adjusting for availability of safety equipment at the workplace, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience. The alpha (α) significant level was $p < 0.05$ and the odd ratio computed at confidence interval of 95% (CI).

RQ2: Is there an association between blood lead level and safety practices of battery technicians controlling for the covariates (availability of safety equipment, battery charger education level, knowledge of the importance of safety practices on lead poisoning, location of the workshops [either in the organized or roadside setting], and years of experience)?

$H_0 2$: There is no association between blood lead levels and safety practices status of battery charging technicians controlling for the covariates (availability of safety equipment, battery charger education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

$H_a 2$: There is an association between blood lead levels and safety practices status of battery charging technicians controlling for the covariates (availability of safety equipment, battery charger education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

The statistical model used was chi-square statistical analysis. It established an association that exists between blood lead levels and safety practices after adjusting for the availability of safety equipment, battery charger education level, knowledge of the importance of safety practices on lead poisoning, the location of the workshop [either in the organized or roadside setting], and years of experience).The alpha (α) significant level was $p < 0.05$ at confidence interval of 95% (CI).

RQ3: Is there an association between the education level of battery technicians and the safety practices on lead poisoning controlling for the technicians safety practices covariates (marital status, technicians income, and technicians location [either in the organized or roadside setting])?

$H_0$3: There is no association between the education level of battery technicians and the safety practices on lead poisoning controlling for the covariates (marital status, technicians income, and technicians location [either in the organized or roadside setting]).

H_a3: There is an association between the education level of battery technicians and the safety practices on lead poisoning controlling for the covariates (marital status, technician's income, and technicians location [either in the organized or roadside setting]).

The statistical model employed was chi-square statistical analysis and it established an association that exists between education attainment and safety practices after adjusting for marital status, technician's income, and technician's location [either in the organized or roadside setting].The alpha (α) significant level was $p < 0.05$ at confidence interval of 95% (CI).

RQ4: Is there an association between knowledge of the importance of safety practices on lead poisoning and utilization of personal protective equipment (PPE) by battery technicians at the workplace controlling for the covariates (age, education level, marital status, years of experience, and location of the workshop [either in the organized or roadside setting])?

$H_0$4: There is no association between knowledge of the importance of safety practices on lead poisoning and utilization of personal protective equipment (PPE) by battery technicians at the workplace controlling for the covariates (age, education level, marital status, years of experience, and location of the workshop [either in the organized or roadside setting]).

H_a4: There is an association between knowledge of the importance of safety practiceson lead poisoning and utilization of personal protective equipment (PPE) by battery charging technicians at the workplace controlling for the covariates (age, marital status, years of experience, and location of the workshop [either in the organized or roadside setting]).

The statistical test used was chi-square statistical analysis, it established an association that exists between knowledge of the importance of safety practices and utilization of personal protective equipment after adjusting for technician age, educational attaintment, marital status, years of experience, and the location of the workshop [either in the organized or roadside setting]). The alpha (α) significant level was $p < 0.05$ at confidence interval of 95% (CI).

RQ5: Is there an association between perceived risk of lead poisoning and utilization of personal protective equipment (PPE) by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning)?

H_05: There is no association between perceived risk of lead poisoning and utilization of PPE by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning).

H_a5: There is an association between perceived risk of lead poisoning and utilization of PPE by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning).

The statistical model used was multivariate logistic regressions statistical analysis, it established an association and the significant difference that exists between perceived risk of lead poisoning and utilization of PPE among battery technicians in the organized and roadside settings after adjusting for technician age, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning). The alpha (α) significant level was $p < 0.05$ at confidence interval of 95% (CI). The Nagelkerke pseudo-R^2 indicated a low goodness of fit as the model accounted for approximately 70% of the variance. The chi-square value indicated no significance difference between battery technicians in the organized and roadside setting with regards to perceived risk and utilization of PPE.

Threats to Validity

The validity of this study is the strength or accuracy of the propositions, inferences, and the conclusions that were drawn from the results, that is, whether the results measured what it was intended to measure (Creswell, 2009). Several factors stated below could have threatened the validity of this study, but effort was put in place to avert any threat to validity:

- The language barrier could exist between the battery technicians and the investigator administering the questionnaire but in this study, I did not encounter language barrier with the battery technicians who participated in the study.

- Using inaccurate population to compute the weighted sample could constitute a threat, but the sample size for this study was accurate as I calculated the sample size with the use of appropriate method based on statistical model selected for the analysis of the sampled population.
- A Battery technician whose workshop is located outside the study setting but on visitation could constitute a threat but I ascertained that those categories of battery technicians were excluded from the study.

External Validity

The external validity of this study refers to the degree to which the conclusions (outcome) of this study could be generalized to other people in other places and at other time. Three major threats that could threaten external validity of this study included the nature of the people, the place and time to which the results of this study is being generalized. The threats to the external validity were improved during this research process as I ensured that random selection was used to sample the studied population and once a subject was selected all necessary effort was put in place to ensure no dropout. Furthermore, the threat to external validity was improved as I conducted thisstudy in a new setting, among battery technicians, and at different time, then the ability to generalize this study results could be stronger.

Internal Validity

Internal validity determines whether or not the association could becausal in nature, and it asserts that variation in the dependent variable originate from the change in the independent variable(s) but not from the covariates factors (Creswell, 2009). The threat from the extraneous factors that allowed for the alternative explanation as to what caused a given effect in the dependent variable was looked for and guided against in this study. According to Creswell (2009), the examples of factors that could constitute threats to the internal validity of this quantitative study includes history, maturation, statistical regression, testing of the instrument, mortality, evaluation anxiety, limited range, confirmation bias, and instrumentation, all these factors were guided against in this study.

Construct Validity

The construct validity of this study refers to how well the operational definition of a variable reflects the meaning of the concept (Creswell, 2009). It is an attempt to generalize the study outcome to the broader concept. The threats to construct validity of this study include hypotheses guessing and evaluation apprehension by the participants. The threat to construct validity was guided against by not communicating the desired outcome of this study to the participants during my interaction in the research process.

Ethical Procedures and Protection of Participants' Rights

I conducted this study after Institutional Review Board of the Walden University (IRB) has approved and allocated a number upon meeting the board requirements. The walden University IRB approval number for this study is 12-05-16-0462777 and it expires on December 04, 2017. The consent form was given to the participants (battery technicians) to read, understand and fill it freely without any interference before participation in the study. The purpose of the implied consent form was to seek for the consent of the participants freely, explaining the nature of the study, and reassuring the participants of their safety. Furthermore, to inform the participants that the survey will not bring any harm, but it could help them on how to improve their safety practices at the workplace. Confidentially was maintained at the beginning, during and at the time of analysis of collected data. The participants'personal identifier such as name and address were not collected during data gathering period.

Summary

Chapter 3 described the research method, material, and procedure that were used in the methodology. This study was a quantitative cross–sectional design, and it assessed the safety practices status of battery technician and the rate of utilization of PPE at the workplace. The participants of this study were battery technicians aged 18 years and above with their workshops located in the designated mechanic village (organized setting) and along the roadside in Ikeja and Agege local government council areas of Lagos, Nigeria, West Africa. The multistage sampling method and systematic sampling technique were used to select the participants. The questionnaire was used to gather the required information from the battery technicians, and the questionnaire was assessed with pilot study and validated by the review of three scholars who are occupational safety specialist before been administered to the participants. The IRB of Walden University approved and allocated anumber to this study before collection of data.

Data collected with questionnaires were analyzed and hypotheses tested. The dependent variable was safety practice (primary outcome), and the rate of utilization of the personal protective equipment (secondary outcome). The independent variables were the workplace conditions, blood lead level, battery technician's education level, technician's knowledge of the importance of safety practices, and perceived risk of lead poisoning. Chapter 4 presented the results of analysis of the data collected on safety practices status of battery technicians and its related variables. The tables of results and data analysis report were presented in a standardized APA format. Chapter 5 presented the discussion of the results in APA format of reporting based on the analyzed data.

Chapter 4: Results

Introduction

The findings of this survey are presented in Chapter 4 based on analyzed data in a way that they answered the research questions and gave the results of the tested hypotheses. The purpose of this study, the research questions, and the hypotheses are stated briefly below. A summary of how data were collected and the sampling procedures used arealso presented. Finally, the descriptive and inferential statistical analyses of thissurvey data are described in detail in this chapter.

Purpose

In this study, I assessed, tested, and described the association that exist between safety practices and workplace condition, blood lead levels, and rate of utilization of PPE, and I compared the safety practices of battery technicians in the organized and roadside settings in Lagos, Nigeria. The battery technicians shared information on the demographic and occupational characteristics, their safety practice history, and their opinion concerning their level of safety practices at the workplace and rate of utilization of the PPE. The safety practice that was identified as a gap in the literature was addressed with the primary data collected with the questionnaires from battery technicians. Research questions and hypotheses of this study are as follows:

RQ1: Is there an association between the workplace conditions of battery technicians and compliance with lead poisoning safety practices (SAFETY)?

$H_0$1: There is no association between workplace condition and compliance with lead poisoning safety practices (SAFETY).

H_a1: There is an association between workplace condition and compliance with lead poisoning safety practices (SAFETY).

RQ2: Is there an association between blood lead levels and safety practices of battery technicians?

H_02: There is no association between blood lead levels and safety practices of battery technicians.

H_a2: There is an association between blood lead levels and safety practices of battery technicians.

RQ3: Is there an association between the education levels of battery technicians and the safety practices on lead poisoning at workplace?

H_03: There is no association between the education level of battery technician's and the safety practices on lead poisoning at the workplace.

H_a3: There is an association between the education level of battery technician's and the safety practices on lead poisoning at the workplace.

RQ4: Is there an association between knowledge of safety practices on lead poisoning and utilization of personal protective equipment (PPE) by the battery technicians at theworkplace?

H_04: There is no association between knowledge of safetypractices on lead poisoning and utilization of personal protective equipment (PPE) by the battery charging technicians at workplace.

H_a4: There is an association between knowledge of safety practices on lead poisoning and utilization of personal protective equipment (PPE) by the battery technicians at the workplace.

RQ5: Is there an association between perceived risk of lead poisoning and utilization of PPE by the battery technicians in the organized and roadside setting?

H_05: There is no association between perceived risk of lead poisoning and utilization of PPE by the battery technicians in the organized and roadside setting.

H_a5: There is association between perceived risk of lead poisoning and utilization of PPE by the battery technicians in the organized and roadside setting.

Pilot Study

The pilot study was conducted using a test-retest method. The questionnaires tested were presented to the selected 50 participants with similar characteristics to the surveyed participants at a location far away and outside the study setting. The reliability rating was verified with 50 questionnaires administered to the same group of selected battery technicians at an interval of 2 weeks at Ibadan, Oyo State, Nigeria. The questionnaires were paired, and the scores for the test and the retest session were computed for their reliability rating using the Pearson Correlation Coefficient (*r*).

The test scores for the questionnaires had an m=64.12% and $SD = \pm$ 10.320 while the retest scores were m= 62.24% and $SD = \pm 8.590$. The test-retest rating was .823, and it was considered a good reliability value for the tested questionnaires. Three forms of validity, face, content, and construct validity of the questionnaire, were assessed and found to be perfect with no revisions required based on the comparison of test and retest questionnaires. There were 14 questions (Questions 8 to 21) related to the workplace conditions and safety practices on lead poisoning. In the pilot study, these group of questions had an *m* = 3.550 and the *SD* = $\pm$ 1.409.

There were 2 questions on blood lead levels and safety practices on lead poisoning (Questions 21 and 43). In Question 21, the *m* = 3.470 and *SD* = $\pm$ 1.505 while in Question43, the *m* = 3.567 and *SD* = $\pm$ 1.412. Questions 4 and 22 to 33 were related to educational attainment and safety practices, and these group of questions had an *m* = 3.530 and *SD* = $\pm$ 1.631. Therewere 7 questions related to the knowledge of safety practices and utilization of PPE (Questions 38 and 39 to 44). In Question 38, the *m* =3.470 and *SD*=$\pm$ 1.505 while in Questions 39 to 44, the *m* = 3.710, and *SD* = $\pm$ 1.534. Two questions were used to compare the rate of utilization of PPE in the organized and roadside setting (Questions 34 and 5). The mean for Question 34 was *m* =3.730 and *SD*=+1.691. In Question 5, the *m* =3.970 and *SD* =$\pm$1.565.

The internal consistency of the questionnaire for this study was determined, that is, how well the questionssynchronized together. This was determined by computing Cronbach’s Alpha reliability coefficient.Cronbach's Alpha is not a statistical test; instead, it is a coefficient of reliability (or consistency) written as a function of the number of test items and the average intercorrelation among the items (Field, 2013). The value of the Cronbach’s Alpha for this study instrument is tabulated in the Tables 3, 4, and 5.

Table 3

Scale Statistics for Questionnaires of Pilot Study of Battery Technicians in Ibadan, Nigeria, December 2016

Variables scale checked	Mean	Variance	*SD*	No of items	No of cases
Workplace conditions	19.35	23.841	5.781	14	50
Safety practices on lead poisoning	17.01	11.487	5.238	13	50
Availability of PPE at workplace	7.24	14.409	2.796	04	50
Knowledge of Lead poisoning safety	12.97	5.109	3.250	06	50

Note. SD = standard deviation

Table 4

Item-Total Statistics for Questionnaires of Pilot Study of Battery Technicians in Ibadan, Nigeria, December 2016

Variables items checked	Scale variance if item deleted	Square multiple correlation	Cronbach's Alpha if item deleted
Workplace conditions	20.354	.402	.783
Safety practice on lead poisoning	9.158	.568	.875
Availability of PPE at workplace	2.755	.371	.727
Knowledge of Lead poisoning safety	6.393	.469	.743

*Note.*The figure inputs into this table were from item-total statistics output of Cronbach's Alpha run on variables item checked with the row of the lowest figure selected.

Cronbach's Alpha analysis was conducted for the purpose of ascertain the reliability of the items in the questionnaire that is their internal consistency (how well the items hang together). From the scale statistics Table 3, the *N* value (number of cases) is 50, and there was no missing *N* value during the pilot study. In the analysis, I examined to what extent the items in the variables (workplace conditions, safety practices on lead poisoning, availability of PPE at the workplace, and knowledge of the importance of lead poisoning safety) showed internal consistency. The mean, variance, standard deviation, and the number of items in the variables analyzed were presented in Table 3.

Table 5

Reliability Coefficients for Questionnaires of Pilot Study of Battery Technicians in Ibadan, Nigeria, December 2016

Variables items checked	Alpha	No of items	No of cases
Workplace condition	.815	14	50
Safety practice on lead poisoning	.971	13	50
Availability of PPE at the workplace	.785	04	50
Knowledge of Lead poisoning safety	.819	06	50

In addition, the correlations of the items in the variables arepresented in Table 4 (item-total statistics**),** which were the statistics for the relationships between individual items and the whole scale. The important bits for this analysis are the last two columns. Corrected item-total correlations are the correlations between the scores on each item and the total scale scores. It was observed that workplace conditions, safety practices on lead poisoning, availability of PPE at the workplace, and knowledge of the importance of lead poisoning safety after running the Cronbach’s Alpha on the questions, if items were deleted, the score results were high,.783, .875, .727 and .743 respectively. Therefore, the scale was internally consistent for those variables with reasonably high correlations. In this case all correlations were.7 or more, indicating good internal consistency. The final column also indicated what Cronbach's Alpha would be if an item was deleted and recalculated from the remaining items in the tested variables.

Furthermore, the reliability coefficients in Table 5 give the overall Cronbach's Alpha reliability coefficient for the set of items in the variables analyzed at .815, .971, .785, and .819, and these values indicated good internal consistency. In summary, the items in workplace conditions, safety practices on lead poisoning, availability of PPE at the workplace, and knowledge of the importance of lead poisoning safety practices showed strong reliability with a high alpha value. Conclusively, the pilot study test did not warrant any significant review of the survey instrument. Therefore, the study instrument, data collection protocol, the method, and sampling technique adopted were all appropriate for the study. Hence, I commenced the data collection as planned.

Data Collection

The data collection for this study was carried out by me for 6 weeks, and there were no discrepancies from the plan presented in Chapter 3. The battery technicians aged 18 years and above, with their workshops located in the organized and roadside settings of the two selected local government council areas (Ikeja and Agege) of Lagos, Nigeria were recruited. The multistage sampling method was used to delimit the population size of the selected local government council areas studied. The study participants were selected with the systematic sampling technique. Questionnaires with close-ended questions were administered to the participants to collect the required information for the study.

The minimum sample size calculated for this study in Chapter 3 was 250, but I administered 300 questionnaires and 293 participants successfully returned the completed questionnaires. The reason for administering 300 questionnaires was to protect the study against the threat ofexternal validity so that the results of the study could be generalized to the entire battery charging population in Lagos, Nigeria. Safety practices status was measured by the availability of safety materials and utilization of PPE at the workplace through recall reported in the questionnaires. The battery technicians' compliance with safety practices was measured by their recall of the rate of utilization of PPE at the workplace.

I used a quantitative method, primarily cross-sectional approach to predict the safety practices of battery technicians, and a comparison of the safety practices in the organized and roadside setting was measured with the recall. Furthermore, information on demographic and occupational characteristics of battery technicians likeage, marital status, income, settings of their workshop, education level, years of experience, and knowledge of the importance of safety practices was collected and related to their safety practices at the workplace, and the value of their blood lead levels was equally collected through recall.

Analysis of Data

After completion of the data collection, the questionnaires were collated and a codebook was constructed to describe the locations of the variables. Lists of codes were assigned to the attributes that composed the variables. The cleaning of data was performed to correct the error on the field before importing the data into SPSS. The revising of names and labelsand verification was done to ensure each variable was correctly coded before the extraction of the subset of variables for analysis. The *N* value was 293, there was no missing *N* value, and SPSS software version 21 installed into my computer systemwas used to analyze the data.

The univariate descriptive analysis was used to examine the distribution of each variable while bivariate analysis (X^2) and Fisher's exact test wereused to examine the relationship that exists between the independent and dependentvariables. The multiple logistic regression analysis was used to predict the most significant independent variable associated with lead poisoning safety practices. Backward stepwise multiple regression analysis was used to identify all independent variables related to the outcome variable at a p-value of < 0.05 and 95% Confidence Interval [CI] after adjusting for age, education, marital status, years of experience, monthly income, and knowledge of the importance of lead poisoning safety practices. Confidentiality was maintained to protect the participants' data during the collection, collation, analysis, and throughout the study.

Study Results

Demographic and Occupational Characteristics

The descriptive analysis results of battery technicians' demographic and occupational characteristics are stated in Table 6. A total of 293 surveys were completed by the battery technicians in the two selected local government council areas (Ikeja and Agege) of Lagos, Nigeria. All the battery technicians who participated in the study were N=293. There were n=148 of 293, 50.5% battery technicians from the organized setting while there were n=145 of 293, 49.5% from the roadside setting. The majority of the battery technicians 41%, n=120 of 293 were aged 40 to 49 years old, and the mean age of the 293 participants was 43.6 ± 10.5 and 40.5± 7.6 years for the organized and roadside group respectively.

The majority of the battery technicians who participated in the study reported they were married or living as married couple *n*=260 of 293, 88.7%. More than one-half of the battery technicians *n*=151 of 293, 51.5% reported a high school grade or less education level. The majority of the battery technicians *n*=192 of 293, 65.6%, reported their monthly income was between 21,000 – 40,000 Naira. Most of the battery technicians *n*=110 of 293, 37.5% who participated in the study have between 10-14 years of experience working as a battery charger.

Table 6

Descriptive Analysis Results of Battery Technicians Demographic and Occupational Characteristics Lagos, Nigeria, January 2017

Variable	Workshop setting Organized (*n*=148) Freq. (%)	Workshop setting Roadside (*n*=145) Freq. (%)	*N*=293(%)	Statistical analysis *p*-value
Age group (years)				
< 20	0(0.0)	01(0.34)	01(0.34)	
20-29	22(7.51)	27(9.22)	49(16.72)	
30-39	49(16.72)	45(15.36)	94(32.08)	$p<0.000$
40-49	61(20.82)	59(20.14)	120(40.96)	
50-59	13(4.44)	08(2.73)	21(7.17)	
> 60	03(1.02)	05(1.71)	08(2.73)	
Gender				
Male	148(100)	145(100)	293(100)	
Female	0(0.0)	0(0.0)	0(0.0)	
Marital status				
Married	127(86.0)	129(89.6)	260(88.5)	
Divorced	03(2.0)	01(0.7)	04(1.4)	
Widow	0(0.0)	0(0.0)	0(0.0)	$p < 0.001$
Widower	07(4.5)	02(1.4)	05(1.8)	
Separated	02(1.4)	01(0.7)	03(1.0)	
Single	09(6.1)	12(8.3)	21(7.3)	
Education level				
No formaleducation	05(3.4)	09(6.2)	14(4.8)	
Elementaryschool	35(23.6)	43(29.7)	78(26.6)	
Some high school	19(12.8)	23(15.9)	42(14.4)	$p < 0.000$
High schoolgraduate	83(56.1)	68(46.9)	151(51.5)	
Some College/Technical	05(3.4)	02(1.3)	07(2.4)	
University/College Graduate	01(0.7)	0(0.0)	01(0.3)	
Monthly income (Naira)				
< 20,000	17(11.5)	23(15.9)	40(13.7)	
21,000-40,000	95(64.2)	97(66.9)	192(65.6)	
41,000-60,000	34(22.9)	24(16.6)	58(19.7)	$p <0.042$
61,000-80,000	02(1.4)	01(0.6)	03(1.0)	
> 81,000	0(0.0)	0(0.0)	0(0.0)	
Years of experience				
< 5	13(8.8)	09(6.2)	22(7.5)	
5-9	15(10.1)	17(11.7)	32(10.9)	
10-14	54(36.5)	56(38.6)	110(37.5)	$p >0.923$
15-19	37(25.0)	35(24.2)	72(24.6)	
> 20	29(19.6)	28(19.3)	57(19.5)	

*Note.*FET = Fisher's Exact Test, $p< 0.05$ was considered significant at 95% CI = confidence interval, Freq. = frequency, % = percentage.

Furthermore, Table 6 shows the analysis results of the test of association with Fisher's exact test (FET) for demographic and occupational characteristics of the subjects. The alpha significant level was at $p < 0.05$, and 95% confidence interval. The statistical analysis of the years of experience of battery technician using (two-sided Fisher's exact test) established that there was no statistically significant association between the years of experience and practices of lead poisoning safety, considering 50.5% of subjects in the organized setting, and 49.5% of subjects in the roadside setting ($p > 0.923$, FET). Also, the gender was not statistically significant because the analysis score number in the row cells of female gender are zero, hence the Fisher's exact statistical test did not run because there is no number in atleast one cell of the second row.

Conversely, when considering the 50.5% and 49.5% of the battery technicians in the organized and roadside setting respectively, using (two-sided Fisher's exact test) for the analysis of the demographic and occupational variables like the age ($p < 0.000$, FET), marital status ($p < 0.001$, Fisher's exact test), the education level ($p < 0.000$, FET) and monthly income ($p < 0.042$, FET). It was established that all these variables were statistically significantly associated with safety practices on lead poisoning at the workplace. Conclusively, the gender and years of experience of battery technicians were found not to be statistically significantly associated with safety practices on lead poisoning at the workplace $p > 0.05$. While, the age, marital status, education level, and monthly incomes were statistically significantly associated with the safety practices on lead poisoning at the workplace $p < 0.05$.

Factors Affecting Battery Technicians' Safety Practices at the Workplace

The workplace of battery technicians need to meet an appropriate safety standard which should be adequate for effective control of lead poisoning hazards. This could encourage positive adherence to safety practices but most often time the enabling environment is seldom provided. This session of results presentation examined factors related to workplace conditions, blood lead levels and education level of battery technicians, and its effects on the safety practices on lead poisoning. The descriptive statistics of the distribution of the workplace conditions related to safety practices was shown in Table 7.

The multiple logistic regressions analysis of the workplace conditions and safety practices on lead poisoning was shown in Table 8. The multiple logistic regressions statistical analysis established the association that exists between workplace conditions and safety practices of battery technicians at $p < 0.05$ and 95% confidence interval. Furthermore, the chi-square analysis test shown in Table 8 was used to establish the association that exists between education level, blood lead levels and safety practices of battery technicians at $p < 0.05$ and 95% confidence interval.

Battery Technicians Workplace Conditions

The descriptive statistics analysis result of the distribution of battery technician's workplace conditions was shown in Table 7. The majority of battery technicians n=268 of 293, 91.5% indicated that drinking water was not available in their workplace. More than two-third of battery technicians n=254 of 293, 86.7% reported that soap to wash hand was not available at the workplace. Also, nearly all the battery technicians n=291 of 293, 99.3% indicated that no single use towel was provided to dry hands and body at the workplace.

The majority of battery technicians *n*=281 of 293, 95.9% reported that there was water to wash hands while working in the workshop. Nearly all the battery technicians *n*=275 of 293, 93.9% indicated that washing water was separated from drinking water at the workplace. More than two-third of the battery technicians *n*=278 of 293, 94.9% reported that water and place to bath after daily work activities was not available. The majority of battery technicians *n*=291 of 293, reported that information on danger associated with lead poisoning was not pasted on the wall at the workplace and could not be seen.

More than two-third of battery technicians *n*=215 of 293, 73.4% reported that boss did not talk to them about precaution to follow on lead poisoning safety and the need to use PPE at the workplace. Similarly, the majority of battery technicians *n*=265 of 293, 90.4% indicated that they contact lead fumes when smelting battery lead cells at the workplace. Also, more than two-third of the battery technicians *n*=283 of 293, 96 .6% indicated that they contact lead particles when washing battery cells. Nearly all the battery technicians *n*=275 of 293, 93.9% reported contact with lead fumes when repairing lead cells at the workplace. Two-third of the battery technicians *n*=200 of 293, 68.3% indicated that they do swallow sweat droplet off the face while smelting lead cells in the workplace. Table 7 shows factors that were associated with workplace condition and safety practices on lead poisoning in Lagos.

Table 7

Distribution of Factors Associated With Battery Technicians Workplace Conditions Lagos, Nigeria, January 2017

Battery technicians'workplace conditions(*N*=293)	Yes	No
	Freq. (%)	Freq. (%)
Drinking water available at workplace	25(8.5)	268(91.5)
Soap available for hand washing at workplace	39(13.3)	254(86.7)
Single use towels available to dry hands and body	02(0.7)	291(99.3)
Water to wash hands available while working	281(95.9)	12(4.1)
Washing water separated from drinking water	275(93.9)	18(6.1)
Water and place to bath after work available	15(5.1)	278(94.9)
Information pasted on lead poisoning could be seen	03(1.0)	290(99.0)
Boss talk to you about lead poisoning safety	78(26.6)	215(73.4)
Contact lead fume when smelting batterylead cells	265(90.4)	28(9.6)
Contact lead particles when washing battery cells	283(96.6)	10(3.4)
Contact lead fume when repairing lead cell	275(93.9)	18(6.1)
Swallow sweat off face while smelting lead cells	200(68.3)	93(31.7)
Breathe in lead fumes in the air while working	213(72.7)	80(27.3)
Engineering/ventilation/administrative control available	02(0.7)	291(99.3)

Note. YES = positive response, NO = negative response, Freq. = frequency.

Furthermore, battery technicians *n*=213 of 293, 72.7% reported that they do breathe in lead fumes in the air while working in the workplace. Only two battery technicians *n*=02 of 293, 0.7% in the organized setting indicated they have lead poisoning control method available in their workplace. The majority of battery technicians *n*=291 of

293, 99.3% in both organized and roadside setting indicated that no control method against lead poisoning was installed in their workplace, instead they reported that they depend on PPE to protect themselves. The problem with this claim was that about ninety-five percent of the battery technicians did not possess basic PPE (hand glove, eye goggles, nose mask, overall cloth and covered shoe) as they indicated poor utilization of PPE at the workplace.

Battery Technicians' Workplace Conditions and Safety Practices

A safety practice at the workplace of battery technicians implies "utilize safety facilities in the work environment to protect yourself" from lead poisoning. This could be achieved by complying with all safety precaution and is the key step towards prevention of the workplace hazards that are detrimental to workers health. The statistical analysis result of the backward stepwise multiple logistic regressionsrun on battery technician's workplace conditions associated with use of lead poisoning safety practices (SAFETY) was shown in Table 8.

Battery technicians that reported the availability of restricted work area in the workshop were 6.8 times more likely to comply with lead poisoning safety practices compared to battery technicians that reported no restricted areas available with *AOR* : 6.8, 95% CI: 3.20-17.53, $p < 0.001$. Also, battery technicians that followed directive about keeping out of restricted areas in the workshop were 4.3 times likely to follow safety information comparedto battery technicians that indicated they had no information on restricted areas with *AOR*; 4.3, 95% CI: 2.31-9.38, $p < 0.010$. The battery technicians that reported uses of vacuum or wet cleaning in the workshop were 0.04 times more likely to to protect themselves from inhalation of lead fumes/particles/dust at the workplace compared to battery technicians that do not use vacuum or wet cleaning of battery lead cells *AOR*: 0.04, 95% CI: 0.00-0.57, $p < 0.042$.

Similarly, battery technicians that reported washing of hands before eating, drinking, smoking and chewing were 9.4 times more likely to comply with lead poisoning safety practices at the workplace compared to battery technicians that did not wash hands before eating, drinking, smoking and chewing with *AOR*: 9.4, 95% CI: 2.07-42.95, $p < 0.000$. The battery technicians that reported use of respirator while working on battery lead cells were 5.3 times more likely to protect themselves from inhalation of lead fumes/dust at the workplace compared to battery technicians that did not use respirator while working on battery lead with *AOR*: 5.3, 95% CI: 1.45-19.04, $p < 0.021$.

The battery technicians that wash hands with soap and water were 5.8 timesmore likely to practices safety on lead poisoning at the workplace compared to battery technicians that do not wash hands with soap and water with *AOR*: 5.8, 95% CI: 1.26-27.21, $p < 0.001$. Battery technicians that reported wearing of overall clothes that protect their body from contact with lead particles/dust/fumes and in case lead solution spilled on them while working were 12.9 time more likely to adhere to safetypractice on lead poisoning compared to the battery technicians that would not wear overall protective clothes at the workplace with *AOR*: 12.9, 95% CI: 2.94-56.8, $p < 0.002$.

Table 8

Multiple Logistic Regression Analysis Results of Battery Technicians' Workplace Conditions Associated With Use of Lead Poisoning Safety Practices (SAFETY) Lagos, Nigeria, January 2017

Independent variable Workplace conditions	Dependent variable Lead poisoning safety Unadjusted *OR* (95% CI, *N*=293)	practices (SAFETY) Adjusted *OR* (95% CI, *N*=293)	Statistical analysis *p*-value
Working/restricted areas available in the workshop			
NO	5.35(2.91-9.87)	6.83(3.20-17.53)	$p < 0.001$
YES	Reference		
Follow directive of keeping out of restricted areas			
NO	2.59(1.81-4.10)	4.31(2.31-9.38)	$p <0.010$
YES	Reference		
Use vacuum/wet cleaning in the workshop			
NO	0.21(0.3-1.70)	0.04(0.00-0.57)	$p <$0. 042
YES	Reference		
Eat/drinking/chewing in the workshop areas daily			
NO	0.30(0.13-0.59)	0.06(0.01-0.24)	$p < 0.003$
YES	Reference		
Wash hands before eating/drinking/chewing			
NO	5.33(1.50-19.0)	9.43(2.07-42.95)	$p < 0.000$
YES	Reference		
Uses respirator while working on battery lead			
NO	2.82(1.10-7.25)	5.25(1.45-19.04)	$p < 0.021$
YES	Reference		
Wash hands with soap and water			
NO	7.42(1.64-29.07)	5.81(1.26-27.21)	$p <0.001$
YES	Reference		
Put on clean clothes after work			
NO	0.35(0.07-1.81)	NS	$p > 0.082$
YES	Reference		
Wash work cloth separately from other cloth			
NO	3.67(0.94-13.25)	NS	$p > 0.067$
YES	Reference		

Table 8 continues

Independent variable Workplace conditions	Dependent Variable: Lead poisoning safety practices (SAFETY) Unadjusted *OR* (95% CI, *N*=293)	Adjusted *OR* (95% CI, *N*=293)	Statistical analysis *p*-value
Wears overall to protects body from lead dust			
NO	7.41(2.23-24.60)	12.93(2.94-56.8)	$p < 0.002$
YES	Reference		
Change into clean cloth immediately lead spill			
NO	0.32(1.55-10.29)	NS	$p > 0.778$
YES	Reference		
Have and follow code of safety practices at the workplace			
NO	5.55(2.23-13.87)	6.35(2.31-17.42)	$p < 0.001$
YES	Reference		
Monitoring inspector visited workshop in past months			
NO	1.75(0.94-14.25)	NS	$p > 0.635$
YES	Reference		
Boss talk about lead poisoning safety			
NO	11.20(1.43-102.70)	NS	$p > 0.085$
YES	Reference		

Note. p< 0.05 was considered significant at 95% CI = confidence interval, OR = odds ratio, *AOR* = adjusted odds ratio. Model adjusted for all covariate variables (age, education, year of experience, monthly income, and availability of safety equipment, and knowledge of lead poisoning safety practices), NS: Not Significant.

Furthermore, the battery technicians with code of safety practices available in their workshop were 6.3 times more likely to comply with the safety practices on lead poisoning compared to battery technicians that did not have code of safety practices available in their workshop *AOR*: 6.3, 95% CI: 2.3- 17.42, $p < 0.001$. Independent variables like put on clean clothes after work, wash work clothes separately from other clothes, change into clean cloth immediately the cloth wore is contaminated, monitoring battery technicians workshop by the occupational inspectors, and boss talk about lead poisoning safety were all not statistically significant to the safety practices on lead poisoning in this current study as $p > 0.082$, $p > 0.067$, $p > 0.778$, $p > 0.635$, and $p > 0.085$ respectively. Overall, there is statistically significant association that exists between variables of the workplace conditionsand safety practices at $p < 0.05$.

Results Related to Research Question 1

RQ1: Is there an association between workplace conditionsof battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience)?

$H_0$1: There is no association between workplace conditionsof battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

H_a1: There is an association between workplace conditionsof battery technicians and compliance with lead poisoning safety practices (SAFETY) controlling for the covariates (availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

Table 8 shows the results of multiple logistic regression analysis used to test the hypothesis 1. Considering workplace conditions 14 independent variables and adjusting for the covariate variables that were significant with safety practices on lead poisoning at the workplace from the two-way table. There was a statistical significant association that exists between8 independent variables of workplace conditions out of the 14 variables examined for safety practices on lead poisoning at the workplace with their $p < 0.001$, $p < 0.010$, $p < 0.042$, $p < 0.003$, $p < 0.000$, $p < 0.021$, $p < 0.002$, $p < 0.001$.

The null hypothesis is rejected for significant variables while research hypothesis that there is an association between workplace conditions and compliance with lead poisoning safety practices (SAFETY) by battery technicians is upheld. The covariates were the availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, the location of the workshop [either in the organized or roadside setting], and years of experience).

Blood Lead Levels and Safety Practices

Table 9 shows the distribution of battery technician's blood lead levels in the organized and roadside setting. Less than ten percent of battery technicians n=26 of 293, 8.9% reported blood lead levels of ≤ 5.0µg/dL in the organized and roadside settings. The battery technicians n=21 of 293, 5.4% with the lowest range of blood lead level belong to the roadside setting. Majority of battery technicians n=135 of 293, 46.1% reported blood lead level of range 6-40µg/dL while fifty-eight battery technicians *n*=58 of 293, 19.8% reported blood lead level of range 41-80µg/dL. Finally, battery technicians *n*=45 of 293, 18.8% indicated they have no idea of their blood lead levels.

Table 9

Distribution of Battery Technicians' Blood Lead Levels Reported Lagos, Nigeria, January 2017

Blood lead levels (µg/dL)	Workshop setting: Organized Freq. (%)	Workshop setting: Roadside Freq. (%)	*N*=293 (%)
≤ 5	05(3.4)	21(14.5	26(8.9)
6 – 40	78(52.7)	57(39.3)	135(46.1)
41 – 80	36(24.3)	22(15.2)	58(19.8)
≥ 81	08(5.4)	11(7.6)	29(9.9)
No idea	21(14.2)	24(23.4)	45(18.8)
Total	148	145	293(100)

Note. µg/dL = microgram per decillitre, Freq. = frequency, % = percentage

Table 10 shows the chi-square statistical analysis result of the test of an association that exists between blood levels and safety practices on lead poisoning. The majority of battery technicians *n*=262 of 293, 85.32% have poor practices on lead poisoning safety at the workplace while just fouteen percent of battery technicians *n*=31 of 293, 14.68% have good safety practices on lead poisoning at the workplace. There is a significant statistical association between practices of lead poisoning safety at the workplace and blood lead levels X^2=24.760, df=4, $p < 0.000$ at 95% confidence interval. This is demonstrated as shown in Table 10 with $p < 0.05$.

Table 10

Two-Way Chi-Square Analysis Results of Battery Technicians Blood Lead Levels and Safety Practices on Lead Poisoning Lagos, Nigeria, January 2017

Blood lead levels	Lead poisoning safety practices: Poor practices (< 50%) Freq.(%)	Good practices (≥70%) Freq.(%)	N=293 (%)	Statistical analysis X^2 p-value
≤ 5	09(3.07)	17(5.8)	26(8.87)	24.760
6 – 40	128(43.69)	07(2.39)	135(46.08)	p< 0.000
41 – 80	50(17.06)	08(2.73)	58(19.8)	
≥ 81	23(7.85)	06(2.05)	29(9.9)	
No idea	40(13.65)	05(1.71)	45(15.36)	
Total	262(85.32)	31(14.68)	293(100)	

Note. p< 0.05 was considered significant at 95% CI= confidence interval, Freq. = frequency, % = pecent

Results Related to Research Question 2

RQ2: Is there an association between blood lead levels and safety practices of battery technicians controlling for the covariates (availability of safety equipment, battery charger education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience)?

$H_0$2: There is no association between blood lead levels and safety practices of battery technicians controlling for the covariates (availability of safety equipment, battery charger education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

H_a2: There is an association between blood lead levels and safety practices of battery technicians controlling for the covariates (availability of safety equipment, battery charger education level, knowledge of the importance of safety practices on lead poisoning, location of the workshop [either in the organized or roadside setting], and years of experience).

Table 10 shows the results of chi-square analysis that was used to test the hypothesis 2 with the two-way table. There was statistical significant association X^2=24.760, df=4, $p < 0.000$, 95% CI between blood lead levels and safety practices on lead poisoning. The null hypothesis is rejected while research hypothesis that there is an association between blood lead levels and safety practices on lead poisoning (SAFETY) is upheld. The covariates were the availability of safety equipment, battery charger education level, battery technicians income, knowledge of the importance of safety practices on lead poisoning, the location of the workshop [either in the organized or roadside setting], and years of experience).

Battery Technicians' Education Level and Safety Practices

Table 6 shows the descriptive statistics of battery technicians while Table 11 below shows the chi-square statistical test of association that exist between education level and safety practices on lead poisoning among battery technicians. In this current study, battery technicians *n*=14 of 293, 4.8% reported they had no formal education. One-third of the battery technicians *n*=78 of 293, 26.6% reported they attended elementary school. Few battery technicians *n*=42 of 293, 14.4% reported they could not complete their high school. More than half of the population of the battery technicians *n*=151 of 293, 51.5% who participated in this study reported they were high school graduate. The minority of battery technicians *n*=07 of 293, 2.4% reported they had college/technical education attainment, but one battery technician *n*=01 of 293, 0.3% reported he is a university/college graduate. In comparison, the battery technicians *n*=83 of 148, 56.1% in the organized setting were high school graduate while less than half of the battery technicians *n*=68 of 145, 46.9% in the roadside setting reported they were high school graduate. Conclusively, more than half the population of battery technicians *n*=151 of 293, 51.5% who participated in this study were high school graduate.

Table 11

Chi-Square Analysis Results of Battery Technicians Education Level and Safety Practices on Lead Poisoning Lagos, Nigeria, January 2017

Variable Battery technician education level	Lead poisoning safety practices Poor practices (< 50%) Freq.(%)	 Good practices (≥ 70%)Freq.(%)	 *N*=293(%)	Statistical analysis X^2*p*-value
No formal education/Someelementary/Some high School	156(53.24)	08(2.73)	164(55.97)	X^2 = 27.13
				df=1
High school graduate/some college/Technical/ College and university graduate	95(32.42)	34(11.6)	129(44.03)	$p < 0.000$
Total	251(85.67)	42(14.33)	293(100)	

Note. $p < 0.05$ was considered significant at 95% CI= confidence interval, Freq. = frequency

Table 11 shows the chi-square statistical analysis result of the test of an association that exists between education levels and safety practices on lead poisoning. Majority of battery technicians *n*=251 of 293, 85.67% had poor practices on lead poisoning safety at the workplace probably because of the low level of education of the participants, while 14.33% of the battery technicians *n*=42 of 293, had good safety practices on lead poisoning at the workplace considering the education level variable.

There is a significant statistical association that exists between practices of lead poisoning safety at the workplace and education level X^2= 27.13, df=1, p < 0.000 at 95% confidence interval and as shown in Table 11.

Results Related to Research Question 3

RQ3: Is there an association between the education level of battery technicians and the safety practices on lead poisoning controlling for the technician's safety practices covariates (marital status, technician's income, and technicians location [either in the organized or roadside setting])?

$H_0$3: There is no association between the education level of battery technician's and the safety practices on lead poisoning controlling for the covariates (marital status, technician's income, and technician'ssetting location [either in the organized or roadside setting]).

H_a3: There is an association between the education level of battery technician's and the safety practices on lead poisoning controlling for the covariates (marital status, technician's income, and workshop location [either in the organized or roadside setting]).

Table 11 shows the results of the chi-square analysis used to test the hypothesis 3. The association that exists between education attaintment and safety practices on lead poisoning at the workplace was established with the two-way table. There was statistically significant association X^2=27.13, df=1, p < 0.000 between education level and safety practices on lead poisoning. The null hypothesis is rejected while research hypothesis that there is an association between education attainment and safety practices on lead poisoning (SAFETY) is upheld. The covariates were the availability of safety equipment, marital status, battery technicians income, knowledge of the importance of safety practices on lead poisoning, the location of the workshop [either in the organized or roadside setting], and years of experience).

Factors Affecting Battery Technicians' Utilization of Personal Protective Equipment

Effective and efficient utilization of PPE at the workplace could protect battery technicians from lead poisoning related hazard and diseases. Effective utilization of PPE is associated with the following factors: availability of PPE at the workplace, knowledge of safety practices on lead poisoning and awareness of the dangers associated with lead poisoning (perceived risk). These were the factors examined in this session of the results analysis to determine their impact on utilization of PPE at the workplace of battery technicians.

Availability of PPE at the Workplace

Table 12 shows the distribution of PPE available at the workplace of battery techniques in both the organized and roadside setting combined as stated below. The majority of battery technicians n=291 of 283, 99.3% reported non-availability of all PPE required for adequate lead poisoning safety at the workplace. Less than one percent of the battery technicians n=2 of 293, 0.7% indicated they have all the required PPEthat could protect them from exposure to lead poisoning hazards at the workplace. The majority of battery technicians n=273 of 293, 93.2% reported lack of money to purchase PPE as the militating factor preventing them from procuring all required PPE that could protect them from exposure to lead poisoning at the workplace.

Table 12

Distribution of PPE Available at the Workplace of Battery Technicians Lagos, Nigeria, January 2017

Variable PPE reported available at the workplace (*N*=293)	Yes Freq. (%)	No Freq. (%)
Have all Personal Protective Equipment	02(0.7)	291(99.3)
All PPE not available due to lack of money to buy	273(93.2)	20(6.8)
Have regular training on usage of PPE	02(0.7)	291(99.3)
Availability of the following PPE at workplace:		
1. Overall protective cloth available	288(98.3)	05(1.7)
2. Protective hand glove available	08(2.7)	285(97.3)
3. Respirator for breathing available	02(0.7)	291(99.3)
4. Protective eye goggle available	25(8.5)	268(91.5)
5. Protective nose mask available	09(3.1)	284(96.9)
6. Protective shoe/boot available at workplace	06(2.1)	287(97.9)

Note. YES = positive respons, NO = negative response, Freq. = frequency, % = percentage

Less than one percent of battery technicians *n*=02 of 293, 0.7%reported they do have regular training on usage of PPE at the workplace while the majority of battery technicians *n*=291 of 293, 99.3% reported that they do not have regular training on usage of PPE at the workplace. The majority of battery technicians *n*=288 of 293, 98.3indicated that they have overall protectivecloth available to protect them from transdermal exposure to lead poisoning at the workplace. Less than two percent of battery technicians *n*=05 of 293, 1.7% reported they do not have overall protective clothfor protection at the workplace. Less than three percent of battery technicians *n*=08 of 293, 2.7% reported availability of hand glove at the workplace while the majority of the battery technicians *n*=285 of 293, 97.3% reported that they do not have hand glove available at the workplace.

Furthermore, less than one percent of battery technicians *n*=02 of 293, 0.7% reported availability of respirator to protect them against breathing in of lead dust while working at the workplace. The majority of battery technicians *n*=291 of 293, 99.7% reported non-availability of the respirator at the workplace. Similarly, less than ten percent of battery technicians *n*=25 of 293, 8.5% reported the availability of protective eye goggle in the workplace while majority of battery technicians *n*=268 of 293, 91.5% indicated non-availability of protective eye goggle at the workplace.

In addition, three percent of battery technician *n*=09 of 293, 3.1% indicated they have nose /face mask at the workplace. The majority of battery technicians *n*=284 of 293, 96.9% reported nonavailability of face/nose mask at the workplace. Finally, only two percent of battery technician *n*=06 of 293, 2.1% reported the availability and use of covered shoe/boot at the workplace while majority of battery technicians *n*=287 of 293, 97.9 5% reported nonavailabilityof covered shoe/boot for protection at the workplace.

Table 13

Distribution of Battery Technicians Knowledge of Lead Poisoning Safety Lagos, Nigeria, January 2017

Variable	Yes	No
Knowledge of lead poisoning safety(*N*=293)	Freq. (%)	Freq. (%)
Respirator provide protection against lead fumes	13(4.4)	280(95.6)
Ventilator provide protection against lead fumes	19(6.5)	274(93.5)
Knowledge of PPE provide protection against lead poisoning	25(8.5)	268(91.5)
Knowledge of common lead poisoning symptoms	02(0.7)	291(99.3)
Knowledge of appropriate and regular use of PPE	04(1.7)	287(98.6)
Knowledge of diseases associated with lead poisoning	29(9.9)	282(90.1)

Note. YES = positive respons, NO = negative response, Freq. = frequency, % = percentage

Knowledge of the Importance of Lead Poisoning Safety

Table 13 shows the distribution of battery technicians' knowledge of the importance lead poisoning safety. The majority of battery technicians *n*=280 of 293, 95.6% reported lack of knowledge that respirator provides protection against lead fumes at the workplace. Less than five percents of the battery technicians *n*=13 of 293, 4.4% reported they have knowledge that respirator protects against lead fumes inhalation at the workplace. Similarly, the majority of battery technicians *n*=274 of 293, 93.5% reported lack of knowledge ofthe importance of ventilator to lead poisoning safety. Less than seven percent of battery technician *n*=19 of 293, 6.5% said they have knowledge of that ventilator provide protection.The majority of battery technicians *n*=268 of 293, 91.5% reported lack of knowledge of the fact that PPE provides protection against lead poisoning at the workplace. Less than ten percent of battery technician *n*=25 of 293, 8.5%

indicated they have knowledge that PPE provides protection against exposure to lead poisoning.

The majority of battery technicians *n*=291 of 293, 99.3% reported lack of knowledge of common lead poisoning symptoms while less than one percent of battery technicians *n*=02 of 293, 0.7% indicated they have knowledge of symptoms of lead poisoning. The majority of battery technician *n*=287 of 293, 98.6% reported they lack knowledge of the appropriate and regular use of PPE at the workplace. Less than one percent of battery technicians *n*=04 of 293, 1.4% indicated they have knowledge of appropriate and regular use of PPE at the workplace. Similarly, the majority of battery technicians *n*=282 of 293, 90.1% reported lack of knowledge of diseases that were associated with exposure to lead poisoning. Less than ten percent of battery technicians *n*=29 of 293, 9.9% reported they have knowledge of diseases associated with exposure to lead poisoning at the workplace.

Table 14 shows chi-square analysis results of battery technician's knowledge of the importance of lead poisoning safety practices in relation to the utilization of PPE at the workplace. The variants such as battery technicians knowledge of respirator provide protection against lead fumes X^2=10.860, df=1, $p < 0.000$, ventilator provide protection against fumes X^2=33.990, df=1, $p < 0.000$ knowledge of PPE provide protection against lead poisoning X^2=7.752, df=1, $p < 0.005$,knowledge of common lead poisoning symptoms X^2=7.367, df=1, $p < 0.006$, knowledge of appropriate and regular use of PPE X^2=4.419, df=1, $p < 0.035$, and knowledge of diseases associated with lead poisoning

X^2=5.381, df=1, p < 0.020 were all statistically significantly associated with utilization of PPE at the workplace.

Table 14

Chi-Square Analysis Results of Battery Technicians'Knowledge of Safety Practices Associated With Utilization of PPE Lagos, Nigeria, January 2017

Variable Knowledge of lead poisoning safety (*N*=293)	Utilization of PPE (*N*=293) YES (%)	 NO (%)	Statistical analysis X^2 *p*-value
Respirator provide protection against lead fumes			
YES	78(26.62)	64(21.84)	X^2=10.860
NO	54(18.43)	97(33.11)	p<0.000
Ventilator provide protection against lead fumes			
YES	57(19.45)	90(30.72)	X^2=33.990
NO	14(4.78)	132(45.05)	p<0.000
Knowledge of PPE provide protection against lead poisoning			
YES	71(24.23)	75(25.6)	X^2= 7.752
NO	48(16.38)	99(33.79)	p<0.005
Knowledge of common lead poisoning symptoms			
YES	77(26.28)	65(22.18)	X^2= 7.367
NO	58(19.8)	93(31.74)	p<0.006
Knowledge of appropriate and regular use of PPE			
YES	67(22.87)	75(25.6)	X^2= 4.419
NO	53(18.09)	98(33.45)	p<0.035
Knowledge of diseases associated with lead poisoning			
YES	13(4.44)	56(19.11)	X^2= 5.381
NO	75(25.6)	149(50.85)	p<0.020

Note. PPE: personal protective equipment, p< 0.05 was considered significant at 95% CI= confidence interval, YES = positive response, NO = negative response, Model adjusted for all covariate variables (age, education, year of experience, monthly income, availability of safety equipment and workshop setting).

Therefore, battery technicians with adequate knowledge of the importance ofsafety practices on lead poisoning have higher likelihood of compliance with lead poisoning safety practices at the workplace compared to battery technicians that lack the knowledge. Battery technicians' with adequate knowledge of the importance of safety practices on lead poisoning is likely to comply with the utilization of personal protective equipment at the workplace with all $p < 0.05$.

Table 15

Two-Way Chi-Square Analysis Results of Battery Technicians' Knowledge and Rate of Utilization of PPE at the Workplace Lagos, Nigeria, January 2017

Variable	Rate of utilization of PPE		Statistical analysis
	Good practices (< 50%) Freq.	Poor practices (≥ 70%) Freq.	X^2 *p*-value
Full knowledge of lead poisoning (≥ 70%) Freq.	13(4.44)	58(19.8)	
No full knowledge of lead poisoning (< 50%) Freq.	73(24.91)	149(50.85)	$X^2 = 5.401$ $p < 0.018$
Total(*N*= 293)	86(29.35)	207(70.65)	

Note. PPE: personal protective equipment, $p < 0.05$ was considered significant at 95% CI = confidence interval.

Table 15 shows the chi-square statistical analysis result of the test of an association that exists between knowledge of the importance of safety practices and utilization of PPE at the workplace. There was a statistical significant associationthat exist between knowledge of the importance of safety practices and utilization of PPE at the workplace X^2=5.401, df=1, $p < 0.018$ at 95% confidence interval. This is demonstrated as shown in Table 15 with $p < 0.018$. Therefore, battery technicians with knowledge of the importance of safety practices on lead poisoning at the workplace have a high likelihood of using PPE at the workplace compared to those battery technicians that lack knowledge of the importance of safety practices on lead poisoning.

Result Related to Research Question 4

RQ4: Is there an association between knowledge of the importance of safety practices on lead poisoning and utilization of personal protective equipment (PPE) by battery technicians at the workplace controlling for the covariates (age, education level, marital status, years of experience, and location of the workshop [either in the organized or roadside setting])?

$H_0$4: There is no association between knowledge of the importance of safety practices on lead poisoning and utilization of personal protective equipment by battery technicians at the workplace controlling for the covariates (age, education level, maritalstatus, years of experience, and location of the workshop [either in the organized or roadside setting]).

H_a4: There is an association between knowledge of the importance of safety practices on lead poisoning and utilization of personal protective equipment by battery technicians at the workplace controlling for the covariates (age, education level, marital status, years of experience, and location of the workshop [either in the organized or roadside setting]).

There was a statistical significant association that exists between battery technician's knowledge of the importance of lead poisoning safety practices and utilization of PPE at the workplaceat the X^2=5.401, df=1, $p < 0.018$). The null hypothesis is rejected while research hypothesis that there is an association between knowledge of the importanace of safety practices on lead poisoning and utilization of PPE by battery charging technicians at the workplace is upheldcontrolling for the covariates variables (age, education level, marital status, years of experience, and location of the workshop [either in the organized or roadside setting]. Therefore, battery technicians with knowledge of the importance of safety practices on lead poisoning could have a high likelihood of good use of PPE at the workplace compared to those battery technicians that lack knowledge of the importance of safety practices on lead poisoning.

Battery Technicians' Perceived Risk and Utilization of PPE at the Workplace

Table 16 shows the distribution of battery technician's awareness of the dangers associated with lead poisoning"Perceived Risk".The majority of the battery technicians n=255 of 293, 87% reported they were not aware of the dangers associated with exposure to lead poisoning both in the organized and roadside setting. Thirteen percent of the battery technicians n=38 of 293, 13% indicated they were aware of the dangers associated with exposure to lead poisoning. The statistical analysis of the perceived risk associated with lead poisoning and utilization of PPE at the workplace is statisticallynot significant for battery technicians in both organized and roadside setting as the X^2= 0.150, df=1, p > 0.698. Therefore, there is no association between perceive risk and utilization of personal protective equipment by the battery technicians at the workplace.

Table 16

Distribution of Battery Technicians Awareness of Dangers Associated With Lead Poisoning (Perceived Risk) Lagos, Nigeria, January 2017

Variable	Workshop setting			Statistical analysis
	Organized	Roadside		
Perceived risk	Freq. (%)	Freq. (%)	N = 293	X^2 p-value
NO	123(41.98)	118(40.27)	241(82.25)	
YES	25(8.53)	27(9.22)	52(17.75)	X^2=0.150
Total	148(50.51)	145(49.49)	293(100)	$p > 0.698$

Note. YES = positive response, NO = negative response, Freq. = frequency, % = percentage

Table 17 shows the distribution of the rate of utilization of PPE by battery technicians at the workplace. The majority of battery technicians *n*=276 of 293, 91.1% reported they wear overall cloth while working in the workshop. Less than ten percent of battery technicians *n*=26 of 293, 7.9% indicated they do not wear overall protective cloth at the workplace. Less than three percent of the battery technicians *n*=07 of 293, 2.4% reported putting on hand glove while working at the workplace while majority of battery technician *n*=286 of 293, 97.6% reported they do not wear hand glove while working with battery at the workplace. Less than one percent of the battery technicians *n*=02 of 293, 0.7% reported wearing respirator at the workplace while the majority of battery technicians *n*=291 of 293, 99.3 % reported nonutilization of respirator while working at the workplace.

Table 17

Distribution of Rate of Utilization of Personal Protective Equipment by Battery Technicians at the Workplace Lagos, Nigeria, January 2017

Variable	YES	NO
PPE utilized at the workplace (*N*=293)	Freq. (%)	Freq. (%)
Wear protective overall cloth at the workplace	267(91.1)	26(7.9)
Wear protective hand glove while working at the workplace	07(2.4)	286(97.6)
Wear respirator while working at the workplace	02(0.7)	291(99.3)
Wear protective eye goggle while working at the workplace	18(6.1)	275(93.9)
Wear protective nose mask while working at the workplace	06(2.1)	287(97.9)
Wear covered shoe/boot at the workplace	05(1.7)	288(98.3)

Note. YES = positive response, NO = negative response, Freq. = frequency, % = percentage

The majority of the battery technicians *n*=275 of 293, 93.9 % reported nonutilization of protective eye goggle while working at the workplace while less than ten percent of the battery technicians *n*=18 of 293, 6.1% reported they do wear protective eye goggle while working at the workplace. Two percent of battery technicians *n*=6 of 293, 2.1% reported they wear protective nose/face mask while working at the workplace. The majority of battery technicians *n*=287 of 293, 97.9% reported nonutilization of face/nose mask while working at the workshop. The majority of battery technician *n*=288 of 293, 98.3% reported nonutilization of protective cover shoe/boot at the workplace while less than two percent of battery technicians *n*=05 of 293, 1.7% reported that they do wear cover shoe/boot at the workplace.

Table 18

Descriptive Statistics of Battery Technicians' PerceivedRisk and Utilizationof PPE Lagos, Nigeria, January 2017

Variable	M	SD	N
Perceived Risk	3.11	1.769	293
Workplace	2.29	1.622	293

Note. PPE: personal protective equipment, M = mean, SD = standard deviation, N = total no of Subjects

Table 19

Correlation Matrix of Battery Technicians Perceived Risk and Utilization of PPE Lagos, Nigeria, January 2017

Variables	Constant	Perceive	Safety
Constant	1.000	-.783	.494
Perceive	-.783	1.000	-.910
Safety	.494	-.910	1.000

Note. PPE: personal protective equipment

Table 20

Multiple Logistic Regression Analysis Results of Battery Technicians Perceived Risk and Utilization of PPE Lagos, Nigeria, January 2017

Variable	Coefficient	Statistics	P	Exp (B)
Perceive	1.724	6.887	.079	5.606
Safety	- 1.298	3.940	.067	.273
Constant	- 2.947	7.374	.077	.053

Note.PPE: personal protective equipment, perceived Risk, safety*p*> 0 .05

I used the research questions 5 of this study to examine to what extent the variables; perceived risk of lead poisoning safety predicted the likelihood of an increase in the use of PPE by battery technicians at the workplace. The means and standard deviations of the independent variables (i.e., perceived risk of lead poisoning safety) and the dependent variable (i.e., utilization of PPE) are presented in Table 18. In addition, the correlation matrix of the predictor's variables was shown in Table 19. The backward stepwise logistic regression was run on the organized and roadside setting battery technician using the aforementioned variables and the results stated in Table 20.

Table 21

Classification Table of Battery Technicians Perceived Risk and Utilization of PPE in the Organized and Roadside Settings Lagos, Nigeria, January 2017

	Predicted		
Observed	Unprotected	Utilize PPE	Percentage correct
Unprotected	85	11	88.7%
Utilized PPE	08	42	84.3%
Overall percentage			86.0%

Note.PPE: personal protective equipment, this Table was derived from 2nd classification output that account for the iv's and give information for the percentage gained.

Calculation of proportion of error in percentage using Table 21(Overall correction is 86.0%)

Sensitivity = 85/85+11 = 0.8865 = 88.7%

Specificity = 42/8+42 = 0.8431 = 84.3%

The proportion of positive prediction for PPE use = 11/11+42 = 0.2037 = 20.4%

The proportion of negative prediction for unprotected = 85/85+8 = 0.9148 = 92.0%

The logistic regression equation for the organized and roadside setting participants (battery technicians) was entered simultaneously as predictors of perceived risk oflead poisoning safety and PPE utilization by subjects. More specifically, holding all other independent variables constant, for a one-unit increase in lead poisoning safety for the organized setting participants; the odds of being a battery technician in the organized setting and using a PPE due to lead poisoning safety were decreased by approximately 20.4%.

Similarly, holding all other independent variables constant, for a one-unit increase in perceived risk for participants in the organized setting, the odds of being in the organized setting and using PPE due to perceived risk of lead poisoningwere increased by approximately 92.0% though the overall correction prediction was 86.0% which is an improvement over the chance level. Table 21showed the summary of the percentage error correction showed in 2 x 2 contingency. Overall, the model chi-square was found to be insignificant $X^2 = 8.716$, df = 1, $p > 0\ .065$. Moreover, Nagelkerke pseudo-R^2 indicated a low goodness of fit as the model accounted for approximately 70% of the variance. See Table 20 for the summary of the logistic regression equation variables.

The logistic regression equation for the roadside setting participants was entered simultaneously as predictors of perceived risk of lead poisoningsafety and utilization of PPE used by roadside setting participants (battery technicians). More specifically, holding all other independent variables constant, for a one-unit increase in lead poisoning safety the odds of being a battery technician participant in the roadside setting and using PPE due to lead poisoning safety were decreased by 79.6%.

Similarly, holding all other independent variables constant, for a one-unit increase in perceived risk and the odds of being a battery technician in roadside setting and using a PPE due to perceived risk of lead poisoning were increased by 84.3% though the overall correction prediction was 86.0% which is an improvement over the chance level. Table 21 gave the summary of the percentage error correction showed in 2 x 2 contingency. Overall, the model chi-square was found to be insignificant $X^2 = 5.527$, df= 1, $p > 0\ .075$. Moreover, Nagelkerke pseudo-R^2 indicated a low goodness of fit as the model accounted for 52% of the variance. Table 20 summarized the logistic regression equation variables.

Results Related to Research Question 5

RQ5: Is there an association between perceived risk of lead poisoning and utilization of Personal Protective Equipment (PPE) by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning)?

$H_0$5: There is noassociation between perceived risk of lead poisoning and utilization of PPE by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning).

H_a5: There is an association between perceived risk of lead poisoning and utilization of PPE by battery technicians in the organized and roadside setting controlling for the covariates (age, education level, battery technician income, years of experience, and knowledge of the importance of safety practices on lead poisoning).

The chi-square statistical analysis of the perceived risk associated with exposure to lead poisoning and utilization of personal protective equipment is statistically not significant for battery technicians $X^2= 0.150$, df=1, $p > 0.698$. Therefore, there is no association between perceived risks of lead poisoning and utilization of personal protective equipment at the workplace. Furthermore, the logistic regression analysis results comparing the utilization of PPE as a result of perceived risk associated with lead poisoning among the battery technician's participants in the organized and roadside setting was found to be insignificantfor both the organized at $X^2 = 8.716$, df = 1, $p > 0$ .065 and roadside setting at $X^2 = 5.527$, df= 1, $p > 0$ .075, as the $p > 0.05$. Therefore, the results of comparison show that there is no difference in the rate of utilization of personal protective equipment in both organized and roadside setting as the Nagelkerke pseudo-R^2 indicated a low goodness of fit.

Testing Hypothesis 5 for Type II Error

Hypothesis 5 compared battery technician's rate of utilization of personal protective equipment in the organized and roadside setting as a result of perceived risk. Based on the run of the statistical test on hypothesis 5, the average workplace safety practices (i.e. utilization of PPE) is 2.29 among battery technicians. A sample size of N=293 battery technicians has a mean of perceived risk =3.11 at the workplace at analpha $\alpha = 0.05$, the claim that perceived risk increases utilization of PPE is more than 2.29 in the workplace is tested below and assuming that $\sigma=10$. Figure 3 illustrate no rejection of $H_0 5$.

Step 1: state hypothesis

$H_0 5$: $\mu \leq 2.29$

$H_a 5$: $\mu > 2.29$

Step 2: Critical value

Since this is a one-tailed test and the alpha level is 0.05, we know from t-distribution table that critical value is 1.65

Step 3: Computation of test value

Formulais $z = \frac{\bar{x} - \mu}{\sigma/\sqrt{n}}$

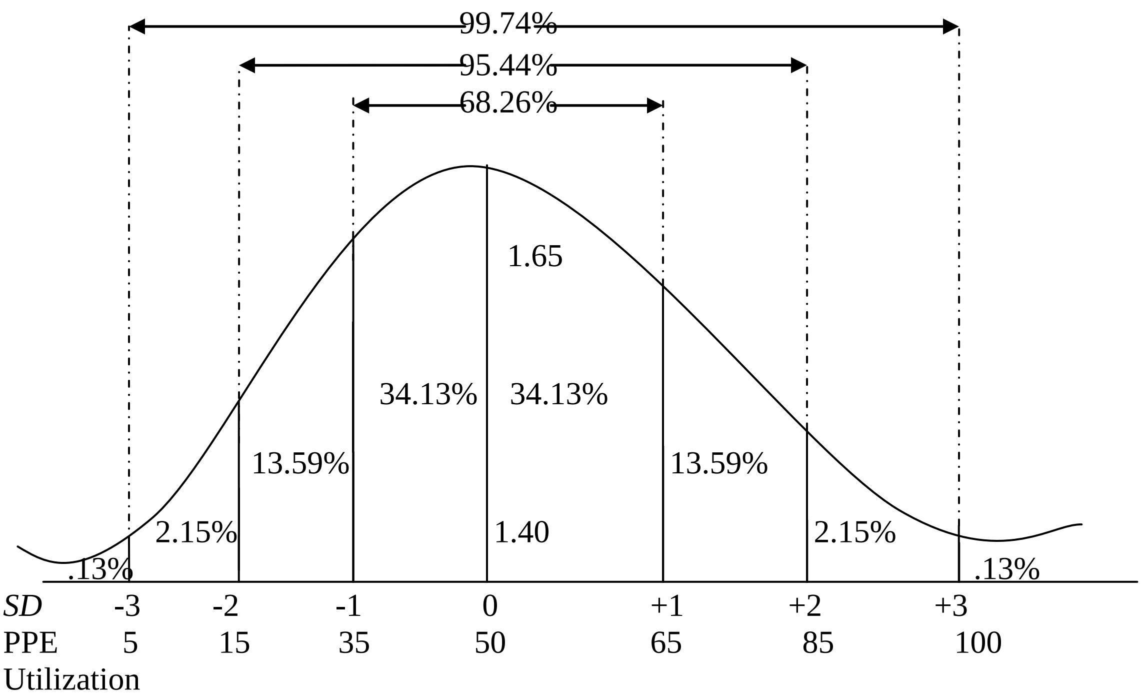
$$z = \frac{3.11 - 2.99}{10/\sqrt{293}}$$

$$z = \frac{0.82}{0.584} \quad z = 1.40$$

Step 4: Decision making

Critical value CV = 1.65

Test Value TV = 1.40



Note. Critical Value is in non-critical region; therefore, the null hypothesis was not rejected.

Figure 3.One-tailed standard curve for Type II error checking for hypothesis 5, February 2017

Step 5: Summary of finding

There was no enough evidence to support the claim that battery technicians in the organized setting have 2.29 times higher likelihood of utilizing personal protective equipment as a result of perceived risk compared to battery technicians in the roadside setting and vise versa. This is because the Test Value TV=1.40 is to the right of Critical Value CV=1.65 and it is in the non-critical region. Hence, the claim is not true for the participants; battery technicians *N*=293, with assumption that $\sigma = 10$, and using a one-tailed test method. Therefore, type II error could not have been committed on hypothesis 5 tested.

Summary of Findings

A total of 293 battery technicians' who participated in this survey were from the organized and roadside setting. The participants were adult 18 years and above. The workplace condition, blood lead levels, and education attainment were important significant predictors of safety practices on lead poisoning at the workplace. The battery technicians' perceived risk (dangers associated with lead poisoning), knowledge of the importance of safety practices on lead poisoning, and availability of PPE were important significant predictors of the utilization of PPE at the workplace.

Multiple logistic regressions analysis results indicated that battery technicians who followed the directive of "keep-off" the restricted areas in the workplace had significantly higher odds of complying with safety practices on lead poisoning than those who do not follow the directive. The battery technicians that wash hands with soap and water had significantly higher odds of safety practices on lead poisoning than those who do not wash hands with soap and water at the workplace. Battery technicians without PPE were found to have lower odds of safety practices on lead poisoning than those who had PPE available in the workplace.

The study findings based on the reviewed data in the light of 5 hypotheses testedindicated that workplace condition, blood lead levels and education attainment of battery technicians had been shown to be statistically significantly associated with safety practices on lead poisoning. The findings also indicated that battery technician's knowledge of the importance of safety practices on lead poisoning and perceived risk (dangers associated with lead poisoning) were statistically significantly associated with utilization of PPEat the workplace. Furthermore, the rate of utilization of PPE in the organized and roadside setting was compared using backward stepwise logistic regressions; it was found out that there was no statistically significant difference in the rate of utilization of PPE in the organized and roadside setting.

Other significant covariate variables were the marital status, age, battery technician's monthly income, and knowledge of the importance of safety practices on lead poisoning. Gender and years of experience were not statistically significantly associated with safety practices on lead poisoning. Similarly, chi-square test of an association indicated the following covariate variables were statistically significantly associated with the utilization of PPE at the workplace: availability of PPE, marital status, age, monthly income, and battery technician's knowledge of the importance of the safety practices on lead poisoning.

Covariate variables like workshop located in either organized or roadside setting, gender, and years of experience were not statistically significantly associated with battery technician's rate of utilization of PPE. In Chapter 5, the discussions, interpretation of the results, recommendations, conclusions, implications of the study for positive social change, and the recommendations for future research and professional decisions-making were presented.

Chapter 5: Discussion, Conclusions, and Recommendations

Discussion Overview

Chapter 5 covers the discussion, interpretation of the findings, implications of the study, recommendations, and conclusions. This quantitative population based cross-sectional survey was conducted to address the gap in knowledge identified in the literature on the multilevel factors that influence safety practices on lead poisoning and the utilization of PPE. Maintaining due diligenceon safety practices could protect battery technicians from the hazards/risksassociated with exposure to lead poisoning at the workplace in Lagos, Nigeria. A total of *N*=293 battery technicians from the organized (*n*=148, 50.5%) and roadside (*n*=145, 49.5%) settings participated in this study. The mean age of 293 participants was 43.6 $\pm$ 10.5 and 40.5$\pm$ 7.6 years for both the organized and roadside setting groups respectively.

In Nigeria, most technicians/artisans who were self-employed seldom show adherence to safety practices and utilization of PPE at their workplace; overall protective cloth are commonly used (Abdulsalam et al., 2015). Based on the extensive literature search before the commencement of this study, no prior research was dedicated to battery technicians'safety practices on lead poisoning at the workplace in Lagos with a focus on multilevel factors that were affecting safety practices andutilization of PPE among battery technicians in the area. As a result of the identified gap in the literature, I conducted this study with the main purpose to investigate several areas of concern regarding workplace conditions, blood lead level, perceived risk associated with lead poisoning, and rate of utilization of the PPE at the workplace of battery technicians in Lagos, Nigeria.

Summary of the Key Findings

In this study, 5 research questions were addressed, and multilevel factors affecting battery technicians' compliance with safety practices on lead poisoning at the workplace were examined. Others factors included blood lead levels, education level, monthly income, age, and marital status as they relate to the battery technicians' safety practices on lead poisoning at the workplace. The findings of this study showed that workplace conditions, education level, and blood lead level are predictors of the safety practice status of battery technicians at the workplace. Furthermore, battery technician knowledge of the importance of safety practices and perceived risk (dangers) associated with lead poisoning were predictors of utilization of PPE at the workplace. There was no significant association between years of experience and the safety practices status of the battery technicians. Finally, the findings of this study indicated that there was no statistically significant difference in the rate of utilization of PPE among battery technicians in the organized and roadside setting.

Interpretation of the Findings

The results from the analysis of this survey data have shown that safety practice status on lead poisoning at the workplace measured through battery technicians' recall is 20%, while the rate of utilization of PPE is 18%. This finding was similar to those of other studies in the southwestern and eastern part of Nigeria. This study is consistent with another study conducted in Nnewi; southeast Nigeria that found that the safety practiceson occupational hazards at the gas station was12.4% (Ibehet al., 2016). Another study on the safety practices on lead occupationally exposed workers was conducted in Ghana with 100 participants (Monney et al., 2014). The study revealed that vehicle repairer artisans have a lower rate of utilization of PPE; just about 27% reported the use of PPE at the workplace (27 of 100; Monney et al., 2014). Conversely, this study finding is not consistent with the findings of a study conducted in Lagos on knowledge, attitude, and safety practices among 142 pipeline products marketing company workers. Even though the participants studied work for corporate petroleum organizations and their education level was high compared to battery technicians, their safety status indicated 85.2% for safety practices on occupational hazards, and 57% for utilization of PPE at the workplace (Adebola, 2014).

The safety practices of occupationally exposed workers in Nigeria is yet to reach the Occupational Health Services and Practice stipulated target of 90% compliance at the organizational and individual level (OHSP, 2013). This low level of safety practices could predispose battery technicians to occupationally related diseases. The needs for regular utilization of PPE by battery technicians cannot be over emphasized in the view of its importance to improve the safety practices on lead poisoning at the workplace. The rate of utilization of PPE at the workplace isa prime index of safety practices performance evaluation (OHSP, 2013). It is of great importance to assess safety practices on lead poisoning, the compliance and rate of utilization of PPE at the workplace of battery workers (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014).

Adherence to safety practices on lead poisoning at the workplace could safeguard battery technicians from health hazards that are related to exposure to lead poisoning and prevent morbidity, disability, and mortality (Pogacean & Pop, 2015). In this study, I clearly identified that 90% of battery technician who were not apprehensive of the risk associated with lead poisoning, and they could not understand the necessity of PPE, availability, and utilization at their workplace. The majority of the battery technicians wear overall clothes as their only PPE applicable. The rate of utilization of PPE recorded in this study was 18%, and this lower rate cannot in any way reasonably make the desired impact on safety practices compliance, improvement, and continuity.

Battery Technicians' Workplace Conditions and Safety Practices

Among the battery technicians, 99% (n=289 of 293) reported nonavailability of an engineering control method while 95.9% (n=281 of 293) reported the availability of water in the workshop to wash hands, but 86% (n=254 of 293) of the participants reported nonavailability of soap to wash hands at the workplace. The results reported in this study clearly identified that battery technician who washes hands with soap and water at the workplace has higher odds *AOR*: 5.8, 95% CI: 1.26-27.21, $p < 0.001$ to comply with safety practices on lead poisoning. Also, battery technicians whowashes hands with soap and water before eating, drinking, smoking, and chewing were found to be statistically significantly associated *AOR*: 9.4, 95% CI: 2.07-42.95, $p < 0.000$ with safety practices on lead poisoning at the workplace.

The outcome on workplace conditions indicated nonavailability of an engineering method at the workplace of battery technicians. In the situation of a developing country like Nigeria where engineering controls or change of work practices to reduce the potential for lead exposure is not feasible or practicable among self-employed workers, then the PPE is required (AOHS, 2013; California Department of Public Health [CDPH], 2014; OHSP, 2013).The workplace environment of battery technicians needs to be improved to avoid a nonfit environment that exposes the technicians to hazards (Perry & Amod, 2011). The self-protective safety behavioral practices need to be improved by imbibing positive behavioral attitudes towards safety practices at the workplace (Adela et al., 2012; Haider & Qureshi, 2013).

Similarly, the outcome of workplace conditions was found to be consistent with that of the study on potential hand–to–mouth exposure to lead in a car battery factory (Pogacean & Pop, 2015). Hand and face washing with soap and water before food/drink or smoking is vital to ascertain safety practices on lead poisoning, as ingestion is one of the three major routes of exposure to lead poisoning at the workplace (Adela et al., 2012; Pogacean & Pop, 2015). Implementing regular hand and face washing at the workplace could reduce exposure to lead contaminants and is less expensive compared to engineering controls, but battery technicians must be properly trained on how to wash their hand with soap properly, regularly, and follow the practices correctly (Adela et al., 2012; Pogacean & Pop, 2015).

The battery technicians whoreported use of vacuum or wet cleaning were 0.04 times more likely to protect themselves from inhalation of lead fumes/particles/dust at the workplace compared to battery technicians whodo not use vacuum or wet cleaning during smelting of the battery lead cells *AOR*: 0.04, 95% CI: 0.00-0.57, $p < 0.042$. Likewise, the battery technicians who reported the use of a respirator while soldering battery lead cells were 5.3 times more likely to protect themselves from inhalation of lead fumes/dust at the workplace compared to battery technicians whodid not use a respirator while working on the battery lead *AOR*: 5.3, 95% CI: 1.45-19.04, $p < 0.021$.

This study outcome on workplace conditionsis related to the work of researchers who emphasized that battery technicians need to protect themselves from the inhalation of lead fumes at the workplace. Haider and Qureshi (2013) stated that the second route of exposure to lead is through inhalation; this occurs during cutting torch to melt leaded solder; heat is generated with vapors and inhalation of lead dust and fumes takeplace during this process, especially when smelting battery lead cells without a face mask. Furthermore, when there is a lack of ventilation to control exposure to airborne lead particles, and if there is a lack of decontamination services at the workplace, then the use of PPE is emphazised to offer protection against lead poisoning (AOHS, 2013). The inhaled lead particles penetrate deeply into the lungs, and the small size allows the body to absorb them quickly, creating the potential for symptom of severe acute lead poisoning (Dongre et al., 2011; Jangid et al., 2012; Singh et al., 2013). If the PPE is put into proper use by battery technicians, there could be an adequate safety practices on lead poisoning at the workplace.

The battery technicians who reported wearing of overall clothes to protect their body and prevent dermal contact with lead particles/dust/fumes and in case lead solution spilled on them while working were 12.9 times more likely to adhere to safety practices on lead poisoning compared to the battery technicians who would not wear overall protective clothes at the workplace *AOR*: 12.9, 95% CI: 2.94-56.8, $p < 0.002$. Ninety-eight percent of the battery technicians (n=288 of 293) reported the availability of overall protective clothes while 91% (n=267 of 293) reported utilization of overalls cloth in the workplace. This study outcome is not consistent with the findings of the study that determined and compared the blood lead levels of automobile technicians in Lagos state, Nigeria. It was discovered that 90% of automobile technicians studied scarcely use overall protective clothes in the workplace (Abdusalam et al., 2015).

Recently, compliance with the provision and utilization of safety facilities at the workplace is one of the prime indexes of assessing the safety practice performance of workers who were exposed to an occupational hazard (OHSP, 2013). Also, improper or lack of adequate control measures, nonprovision of safety equipment, lack of monitoring, no safety training, and lack of medical check up of the battery technicians are safety practices quality indices on lead poisoning inthe workplace (Kuijpet al., 2013). Furthermore, the measure of safety practices in the workplace is an important variable to assess the performance of an occupational safety program (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014). The index (safety practices) measurement is a process of evaluation of the occupational safety program applicable at the workplace; locality, or country (Ajugwo et al., 2014; Kalahasthi et al., 2016). Consequently, the workplace conditions are system factors that can inform the performance of battery technicians on safety practices and utilization of safety facilities available at the workplace.

In addition, I found that battery technicians with the code of safety practices available in their workshop were 6.3 times more likely to comply with the safety practices on lead poisoning as it was found to be statistically significant *AOR*: 6.3, 95% CI: 2.3- 17.42, $p < 0.001$. This study finding on workplace condition is similar to the study on the association between workplace and housing conditions and use of pesticide safety practices and PPE among North Carolina farmworkers (Levesque et al., 2012). Compliance with safety practices in the workplace demand the provision of the required safety facilities and code of safety practices, but utilization of the PPE depends on the knowledge, understanding, and value placed on life. Factors that determine the safety practices on lead poisoning are the enabling environment through the provision of safety facilities, communication, and training on how to use the PPE. Other factors are the lack of money to procure safety equipment, attitude, and understanding (Adela et al., 2012).

Kalahasthi et al. (2016) stated that one of the reasons for noncompliance with safety practices is the lack of monitoring, poor communication, and lack of enforcement on the part of the occupational and safety inspectors who were shadowed with the responsibility by the government. Close observation of many of the state occupational and safety agenciesin Nigeria indicated the problem of logistics as a factor militating against effective monitoring. The motivation of occupational and safety inspectors is crucial to the optimal monitoring of workers whowere exposed to hazard. Harnessing occupational and safety system factors couldimprove battery technicians’workplace conditions and facilitates compliance with safety practices at the workplace.

Independent variables like putting on clean clothes after work, washing work clothes separately from other clothes, changing into clean clothes immediately after the clothes worn are contaminated, monitoring battery technicians’ workplace by the occupational inspectors, and boss talk about lead poisoning safety at the wokplace to subordinate were all not significant to safety practices on lead poisoning in this current study as $p > 0.082$, $p > 0.067$, $p > 0.778$, $p > 0.635$, and $p > 0.085$ respectively. Overall, there was a statistically significant association ($p < 0.001$, $p < 0.010$, $p < 0.042$, $p < 0.003$, $p < 0.000$, $p < 0.021$, $p < 0.001$, $p < 0.002$, $p < 0.001$) between the variables of workplace conditions and safety practices.

In conclusion, the occupational lead exposure in many developing countries is entirely unregulated and often with no monitoring of exposure at the workplace (Abdulsalam et al., 2015; Patil et al., 2013; Rival et al., 2012). The legislation under Alberta's occupational health and safety code has a general and specific requirement related to lead exposure (AOHS, 2013). In Nigeria, there are many small scale battery technicians' who use lead acid based materials that poses a health risk to them, but presently there are no workplace legislation and regulations directed towards these categories of workers (self-employed) against exposure to lead poisoning. The ministry of labor in Nigeria does not have data on lead poisoning, and no occupational exposure limits (OELs) are provided for lead compound, so an appropriate and cost-effective integrated preventive and control measures is urgently required.

Blood Lead Levels and Safety Practices

The mean blood lead level of battery technicians'in this study for the organized setting was 61.2±13.6µg/dL and it was higher than that of the battery technicians in the roadside setting 49.5±9.6 µg/dL. The battery technicians (*n*=21, 8.8%) who reported a low range of blood lead level (≤ 5.0µg/dL) belong to the roadside setting. Majority of battery technicians (*n*=135, 46.1%) reported blood lead level of range 6.0-40.0µg/dL while (*n*=58, 19.8%) reported blood lead level of range 41.0-80.0µg/dL. The majority of battery technicians (*n*=262, 89.4%) had poor practices on lead poisoning safety at the workplace while just twenty percent of battery technicians (*n*=31, 20.6%) had good safety practices on lead poisoning at the workplace. Overall, there was a statistically significant association between blood levels and safety practices on lead poisoning at the workplace X^2=24.760, df=4, $p < 0.000$ at 95% confidence interval.

The outcome of this study is related to the work of the researchers who determined and compared the blood lead levels of automobile technicians in the organized and roadside garages of two local government areas of Lagos state, Nigeria (Abdulsalam et al., 2015). The researchers found that the mean blood lead levels of the battery technicians in the organized setting was 66.0µg/dLand it was higher than that of the battery technicians in the roadside setting 43.5µg/dL (Abdulsalam et al., 2015). It was argued that high blood lead levels of the automobile technicians have a connection with the workplace conditions and safety practices (Abdulsalam et al., 2015).

Similarly, a study conducted in Kenya had an outcome related to this study. Were et al. (2014) examined factors that influence blood lead levels and safety practices among the lead battery workers that were exposed to lead pollutants in Kenya. The study was a prospective longitudinal design with 233 participants from six different industrial plants in Kenya. The blood lead level of the technicians was found to be statistically significantly associated with the type of the industrial plants and safety practices employed (Were et al., 2014). Conversely, the mean blood lead levels of the workers in the six industrial plants was not consistent with the outcome of this study and they were as follows: 183.2 ± 53.6 μg/dL in battery recycling workers, 133.5 ± 39.6 μg/dL in workers of battery manufacturing plant, 126.2 ± 39.9 μg/dL in scrap metal welding workers, 76.3 ± 33.2 μg/dL in paint manufacturing workers, 27.3 ± 12.1 μg/dL in a leather manufacturing workers, and 5.5 ± 3.6 μg/dL in workers of a pharmaceutical plant (Were et al., 2014).

Another retrospective study on lead poisoning safety practices that have related findings to this study was conducted among children below 5years of age in Flint City, Michigan, USA to determine Elevated Blood Lead levels (EBLL) associated with drinking water crisis: A spatial analysis of risk and public health response (Hanna-Attisha, et al., 2016). The study findings revealed a statistically significant increase in the proportion of Flint children with Elevated Blood Lead Level (EBLL) from the time the water source was changed (Hanna-Attisha et al., 2016). Hannah-Attisha et al. (2016) stated that when compared the EBLL of the Flint City children who drank lead contaminated water to the EBLL of the children outside the Flint City who drank uncontaminated water, the change in Elevated Blood Lead Levels (EBLL) was statistically significant (0.7% to 1.2%; $p < 0.05$). The increase in the percentage of the

EBLL of children of the Flint City from 4.0% to 10.6%; $p < 0.05$) was as a result of lack of proper safety practices as the source of the water was contaminated with lead pollutants.

In the past, the OSHA permissible exposure limits of blood lead levels of occupational exposed workers was put at 50.0μg/dL while WHO put the permissible blood lead level value at 40.0μg/dL, and the United States of America Center for Disease Control and Prevention stipulated that the permissible blood lead level valueis 40.0μg/dL (CDC, 2014; OSHA, 2013; WHO, 2014). Presently, the recent studies indicated that there is "no safe limit value" for blood lead leveland the suggested case definition for elevated blood lead level (BLL) is ≤ 5.0μg/dL (ABLES/NIOSH/CDC, 2015; CDC Nationally Notifiable Condition, 2016; CSTE, 2015).

In conclusion, and to support this argument: WHO (2014) stated that engagement in safety practices on lead poisoning could reduce the adverse effect of lead toxicity, and protect both physical, and physiological well-being of the occupationally exposed technicians from associated hazardsand lead-related diseases. It was suggested that the pathways through which battery technicians' cooperate with safety practices at the workplace could influence blood lead level if they adhere to the use of PPE and improvetheir personal hygiene which offerbetter chance of reducing the rate of exposure to lead poisoning at the workplace and is less expensive.

Battery Technicians' Education Level and Safety Practices

In this study, the formal education of battery technicians was classified as follows: the battery technicians' *n*=14 of 293, 4.8% reported they had no formal education. One-third of the battery technicians *n*=78 of 293, 26.6% reported they attended elementary school. Few battery technicians *n*=42 of 293, 14.4% reported they could not complete their high school. More than half of battery technicians *n*=151 of 293, 51.5% reported they were high school graduate.

The minority of battery technicians *n*=07 of 293, 2.4% reported they had college/technical education attainment but just one battery technician *n*=01 of 293, 0.3% reported he was a university/college graduate. In comparison, the battery technicians *n*=83 of 148, 56.1% in the organized setting reported they were high school graduate while less than half of the battery technicians *n*=68 of 145, 46.9% in the roadside setting reported they were high school graduate. Conclusively, more than half of the total population of battery technicians *n*=151 of 293, 51.5% who participated in this study were high school graduate.

The majority of battery technicians *n*=251 of 293, 79.6% who had poor practices on lead poisoning safety at the workplace was probably due to their low level of the education attainment. Less than fifteen percent of the battery technicians *n*=42 of 293, 20.4% had good safety practices on lead poisoning at the workplace. In the chi-square analysis result, there was a statistically significant association between practices of lead poisoning safety at the workplace and education level X^2= 27.13, df=1, p < 0.000 at 95% confidence interval.

This study outcome is consistent with the finding on education attainment of a survey carried out in Lagos. The cross-sectional study was conducted among 142 participants on knowledge, attitude, and compliance with occupational health and safety practices among Pipelines Products and Marketing Company (PPMC) staff in Lagos (Adebola, 2014). The study revealed that 87.4% (118 of 142) of the participants who had post-secondary school education qualification had good occupational safety practices; a high level of education could have influence awareness, knowledge and improve compliance with occupational safety at the workplace (Adebola, 2014). It is, therefore, apparent that an association exists between battery technician’s educational attainment and safety practices on lead poisoning at the workplace controlling for covariate variables.

Conversely, this study outcome on education and safety practices on lead poisoning is not consistent with a survey carried out in Ghana. In a cross-sectional study on occupational health and safety practices among 100 vehicle repairer artisans in an urban area of Ghana, the finding revealed that education level of the artisans was not statistically significant with the participant’s safety practices $p > 0.05$ (Monney et al., 2014). The finding of the study conducted in Ghana could be due to to the influence of proper monitoring of the artisans by the government occupational inspectorate agency, and consequently improved information dissemination on occupational safety practices.

In this current study, the outcome of safety practices on lead poisoning at the workplace of battery technicians reinforced the need for improvement on safety practices, and utilization of PPEin the developing countries. This is a major factor because battery technician's noncompliance with safety measures could be influencing factor on safety practices at the workplace. The low level of educational attainment of an individual who participated in this study could be an influencing factor. Individual with higher degree have a high predisposition to seek for information, understand the information, process it, and use it positively. The educational attainment could influence how an individual care for his/her health, value his/her life, and maintain orderliness in action, and reaction to environmental forces. All these virtues attributed to education attainment could influence the behavior of battery technicians towards positive safety practices on lead poisoning at the workplace.

Battery Technicians' Years of Experience and Safety Practices

The paticipants year of experience was divided into range and n=22, 7.5% of battery technicians' reported they had < 5 years of experience on the job. Ten percent of battery technicians n=32, 10.9% reported they have 5-9 years of experience while about one-third of battery technicians n=110, 37.5% reported 10-14 years of experience. Twenty-four percent of battery technicians n=72, 24.6% reported 15-19 years of experience. Less than 20% of battery technicians n=57, 19.5% reported they had more than 20 years of experience on the job.

Most of the battery technicians who participated in this study had 10-14 years of experience n=110, 37.5%. The Fisher's exact test was used to assess an association that exists between safety practices on lead poisoning and years of experience. Fisher's exact test of association run between years of experience and safety practices indicated no statistical significant association at a level of alpha (p>0.923, Fisher's exact test) and

95% confidence interval. Conclusively, the years of experience of battery technicians was not statistically significantly associated with safety practices on lead poisoning at the workplace $p > 0.923$. The result of this study on the year of experience is consistent with the finding of a study conducted in Ghana. In a cross-sectional study on occupational health and safety practices among 100 vehicle repairer artisans in an urban area of Ghana, the finding revealed that years of experience on the job was not statistically significant with the participant's safety practices at the workplace (Monney et al., 2014).

Battery Technicians' Age and Safety Practices

The participants were divided into six age groups or range. Only one battery technician n=01 of 293, 0.3% reported to be below age 20 years. More than 16% of battery technicians n=49 of 293 reported to be between age 20-29 years. The battery technicians n=94 of 293, 32.1% reported to belong to age group 30-39 years while majority of battery technicians n=120 of 293, 41% reported to belong toage group 40-49 years. About seven percent of battery technicians n=21 of 293, 7.2% reported to belong to age group 50-59 years. Finally, only eight battery technicians n=08 of 293, 2.7% reported age 60 years and above. The mean age of the battery technicians N=293 was 43.6 $\pm$ 10.5 and 40.5$\pm$ 7.6 years in the organized and roadside group respectively.

The Fisher's exact test of association was used to establish an association between safety practices on lead poisoning and age of the participants. The Fisher's exact test of association reported a statistically significant level of p <0.05 at 95% confidence interval. The age of battery technician was statistically significantly associated with the practices of lead poisoning safety (p < 0.000, Fisher's exact test). The result of this study on age is not consistent with the finding of the study conducted in Lagos to determine and compared the blood lead levels of automobile technicians. The study finding reported that no statistical significant association exists between age and blood lead levels of the automobile technicians (Abdulsalam et al., 2015).

Availability of PPE at the Workplace

Among the participants studied, 99.3% of battery technicians *n*=291, reported nonavailability of PPE required for effective lead poisoning safety practices at the workplace. Similarly, the majority of battery technicians *n*=273, 93.2% reported lack of money to buy PPE as the militating factor preventing them from using of PPE that could protect them from exposure to lead poisoning at the workplace. The majority of battery technicians *n*=288, 98.3% reported they have overall protective clothes available for dermal protection against exposure to lead pollutants at the workplace.

Less than three percent of battery technicians *n*=08, 2.7% reported availability of hand glove at the workplace.Furthermore, less than one percent of battery technicians *n*=02, 0.7% reported availability of respirator to protect against breathing of lead dust while working. This study outcome on availability of PPE at the workplace is not consistent with the finding of the study conducted in Kinshasa. The study revealed that the rate of utilization of the PPE at the workplace of battery technicians was 35.6% *n*=96 of 275, and the workplace safety facilities were 41.6% (119 of 275; Tuakuila et al., 2013).

Similarly, 8.5% of battery technicians *n*=25 reported availability of protective eye goggle at the workplace. Also, just three percent of battery technician *n*=09, 3.1%

indicated they have nose /face mask at the workplace. Finally, only two percent of battery technician *n*=6, 2.1% reported availability of covered shoe/boot at the workplace while the majority of battery technicians *n*=287, 95% reported that covered shoe/boot is not available for usage at the workplace. The outcome of this study on availability of PPE is consistent with the finding of a study conducted in India.The rate of utilization of PPE was 24.1% (*n*=24 of 96), and availability of appropriate safety apparatus was 19.5% (*n*=18 of 96; Pogacean & Gurzau, 2014).

Battery Technicians' Knowledge of the Importance of Safety Practices and Utilization of Personal Protective Equipment (PPE) at the Workplace

Among the participants of this study, the majority of battery technicians *n*=280, 95.6% reported lack of knowledge of the importance of respirator that it provides protection against lead fumes at the workplace. Similarly, the majority of battery technicians *n*=274, 93.5% reported lack of knowledge of the importance of ventilator to lead poisoning safety. Also, majority of battery technicians *n*=268, 91.5% reported lack of knowledge on the fact that PPE provide protection against lead poisoning at the workplace. Furthermore, the majority of battery technicians *n*= 291, 99.3% reported lack of knowledge of common lead poisoning symptoms.

The majority of battery technician *n*=291, 99.3% reported lack of knowledge of the importance of appropriate and regular use of PPE at the workplace. Less than ten percent of battery technicians *n*=29, 9.9% reported they have knowledge of diseases associated with exposure to lead poisoning at the workplace. Overall, the battery technicians lack knowledge of the importance of lead poisoning safety practices was statistically significantly associated with utilization of PPE (X^2=5.509, df=1, $p < 0.018$) at 95% confidence interval. Abdulsalam et al. (2015) study findings contrast the findings of these studies, though the researchers found 92% of the participants to be awared of the toxicity of lead poisoning but argued that high proportion of automobile technicians studied scarcely use safety equipment and if at all, it is the overall cloth that they do wear while at the workplace. This type of result is expected because most researchers were unable to differentiate knowledge from awareness. An automobile technician could be aware of the toxicity of lead but may lack in-depth knowledge of the importance of safety practices on lead poisoning, the effect of the lead toxicity, and the needs for the utilization of PPE to safeguard against the long-term intoxication of lead exposure.

This study outcome is consistent with the result of a non-experimental cross-sectional study that investigated workplace self-protective behavior of 320 staff nurses of two university hospital located in Incheon and Kyungi province of South Korean (Kim et al., 2014). The findings of the study showedthat 41.2% of the (n=132 of 320) of the participants who adhered to positive self-protective behavior at the workplace had adequate knowledge of utilization of the PPE (Kim et al., 2014). The compliance could have been associated with in-depth knowledge of the importance of safety practices and the participants' willingness to overcome safety barrier and occupational hazards at the workplace (Kim et al., 2014). This study outcome underpins the importance of training support on safety equipment usage as this would influence the safety practices status of the participants (Kalahasthi et al., 2016; Monney et al., 2014). Lack of information on safety facilities and usage could negatively influence compliance with safety practices and utilization of the required PPEfor lead poisoning at the workplace (Kalahasthi et al., 2016).

The rate of utilization of PPE by battery technicians at the workplace is very low in this study probably because of lack of knowledge on the importance of safety practices on lead poisoning. Less than three percent of battery technicians *n*=07 of 293, 2.4% reported putting on hand glove while working at the workplace while the majority of battery technician *n*=286, 97.6% indicated that they do not wear hand glove while working with battery at the workplace. Less than one percent of the battery technicians *n*=02, 0.7% reported wearing the respirator at the workplace while the majority of battery technicians *n*= 291, 99.3 % reported nonutilization of respirator while working at the workplace.

Similarly, the majority of the battery technicians *n*=275, 93.9 % indicated nonutilization of protective eye goggle. Two percent of battery technicians *n*=6 of 293, 2.1% reported that they wear protective nose/face mask while working at the workplace. The majority of battery technicians *n*=287, 97.9% reported nonusage of face/nose mask while working at the workshop. Furthermore, majority of battery technician *n*=288, 98.3% reported nonutilization of protective covered shoe/boot at the workplace. The commonly use PPE among battery technicians is overall protective clothes. The majority of battery technicians *n*=276, 91.1% reported they wear overall clothes while working in the workshop.

This study outcome is consistent with the cross-sectional descriptive survey in Nnewi town, South Eastern, Nigeria (Ibeh et al., 2016). Over 82.4% (163 of 200) of the participants do not practice safety at the workplace while 66.7% (130 of 200) of the particpants do not have or use safety equipment at their workplace (Ibeh et al., 2016). The common reasons for not practicing safety at the workplace were the lack of information, and the lack of money to buy safety equipment (Ibeh et al., 2016). The rate of utilization of PPE at the workplace could enable occupational safety and health officer to know whether the technicians attained safety practices status, or the utilization of PPE at the workplace is being done in conformity with acceptable norm for safety standard on lead poisoning (Kalahasthi et al., 2016; Pogacean & Gurzau, 2014).

The outcome of this study is related to the study conducted in India by Kalahasthi et al. (2012); the researchers found that 20.2% of the participants complied with safety practices. Findings indicated that utilization of safety facilities is significantly associated with knowledge of health implication of lead toxicity, availability of personal protective equipment, years of experience, educational level, the level of communication, and location of the of the section (Kalahasthi et al., 2012). Similarly, the result of this study is consistent with the finding of the survey conducted on the rate of utilization of PPE. The researchers found that the rate of utilization of PPE was 24.1% (24 of 96), and availability of appropriate safety apparatus was 19.5% (18 of 96; Pogacean & Gurzau, 2014).

Furthermore, the finding of this study was consistent with that of another study conducted in South Africa which stated that automobile technicians see the use of safety apparatus as a stress considering the inconveniences of wearing PPE and the likely allergic reactions, and consequently affect battery technicians’ compliance with regular and appropriate use of PPE (Hess et al., 2013). Another study that was consistent with this study was conducted on knowledge and utilization of PPE. Tuakuila et al. (2013) stated that knowledge deficit of the health implications of lead toxicity and lack of money to buy the PPE were the reasons for poor safety practices at the workplace.

Lack of money to buy PPE might be related to the small income generated from the occupation, being a smallscale business, and knowledge deficit on the toxicity of lead fumes/dust have shown to influence safety practices at the workplaces. In conclusion, there is a need to give regular and adequate information on the toxicity of lead contaminants, the health hazards, and the associated socioeconomic impactof noncompliance with safety practices on lead poisoning. The battery technician's knowledge of the importance of safety practices and education are the significant predictor of adherence to safety practices, and utilization of PPE at the workplace (Pogacean & Pop, 2015).

Battery Technicians'Perceived Risk and Utilization of PPE at the Workplace

The findings on awareness of the risk associated with lead poisoning"perceived risk" and utilization of PPE at the workplace is stated thus; Among the participants studied, the majority of the battery technicians n=255of 293, 87% reported they were not aware of the risk associated with exposure to lead poisoning both in the organized and roadside setting. Thirteen percent of the battery technicians n=38 of 293, 13% indicated they knew the risk associated with exposure to lead poisoning. The statistical analysis of the perceived risk associated with the exposure to lead poisoning and use of PPEwas not statistically significant for battery technicians in both organized and roadside setting with

X^2= 0.150, df=1, $p > 0.698$. There is no difference between the two groups in the perception of risk associated with lead poisoning and use of safety equipment at the workplace. However, the finding on perceived risk could be related to the low level of education of the participants. The battery technicians studied did not understand the risks associated with exposure to lead poisoning, and this could be responsible for the low rate of utilization of PPE at the workplace.

The result of this study on perceived risk and utilization of PPE is consistent with the finding of the study conducted in Pakistan. According to Haider and Qureshi (2013), above eighty-three percent (83.4%, 165 of 200) of the battery technician's studied in Pakistan do not adhered to the safety practices and useof the PPE at the workplace because they were not aware of the risk associated with lead poisoning. Similarly, the finding of this study is consistent with the finding of the study conducted in Lagos, Nigeria. Abdulsalam et al. (2015) indicated that though 92% of the participants studied were aware of the lead poisoning but not the risks associated with lead intoxication. The researchers argued that high proportion of automobile technicians studied scarcely use safety equipment and if at all, it is the overall protective cloth that they do wear while at the workplace (Abdulsalam et al., 2015).

Furthermore, the result of this study is consistent with the finding of Adela et al. (2012) who indicated that lack of awareness of the risk associated with lead poisoning among studied participant's was high in Kenya. Conversely, the finding of this study is not consistent with the finding of Kim et al. (2014) on 320 staff nurses of two university teaching hospital in South Korean on their response to the workplace threat as a result of perceived risk (Kim et al., 2014). The study found that 60.2% (232 of 320) of the participants who adhered to the use of safety measures at the workplace was as a result of awareness of the risk associated with the hazards of their job (Kim et al., 2014).

Possibility of Type I Error

In this study, the statistical inference procedure was performed for 5 hypotheses using the same data sets, and at the same stage of an analysis. Running multiple tests on the same set of data without adjusting the Type I error rate accordingly could increase the chance of obtaining at least one invalid result. Although this is a common error in a research using statistical model to test hypotheses but for this study, necessary steps were taken to avoid committing Type I error, considering 5 hypotheses tested. The guide against committing Type I errors during analysis of this study results was considered and guard against at the pre-planned stage in which α (alpha) also called the bound on Type I error was chosen at $\alpha=0.05$, and confidence interval was 95% as part of the design of the study. Also, errors observed on the data from the field that mighty create problem were corrected before importing into the computer for analysis.

In the analysis stage, the possibility of committing Type I error was equally guarded against by checking the False Discovery Rate (FDR) of the groups of hypotheses tested. Bounding the FDR was adopted for this study because many inferences were performed and the method do not weaken the power of the study. Similarly, consideration of type I errors was emphasized at the planning stage as the power was calculated to determine the number of subjects that gave effect size and power to the study. The power was large enough to detect practically significance difference and any uncertainty.

Statistical model assumptions were satisfied and covariates variables were considered, and no missing *N* value that could create additional uncertainty. The conclusions of this study were reported carefully in transparency manner, not overinterpreted either in the abstract or in the results or conclusions section. Conclusively, Type I error could not have been committed considering all the precautions that were taken during the pre-planning, conduct, analysis, and reporting of the study results.

Interpretation of Findings in Relation to the Theory

The Dejoy (1996) theory of the workplace self-protective behavior applies to the outcome of this study on safety practices. The model diagnosed the behavioral factors needed to drive the development of preventive strategies that is; factors that will facilitate or hinder protective behavior, and this often depends on the antecedents that allow motivation or aspiration to be realized. The theory concludes that the behavior is impacted and this could, in turn, impacts the interconnected factors of the workplace environment, intrapersonal, interpersonal, social support, and social policy (Dejoy, 1996). Interpreting this theory to the finding of this study, the association that exists between workplace conditions (social policy) and safety practices on lead poisoning (behavioral factor) is expected. The indicated relationship between battery technician's blood lead level and educational attainment (intrapersonal) and the safety practices (behavioral factor) is consistent with the fundamental nature of Dejoy workplace self-protective behavior.

Furthermore, the association between knowledge of the importance of lead poisoning safety practices (intrapersonal) and perceived risk (interpersonal) of lead poisoning intoxication and utilization of PPE (behavioral factor) is also consistent with the Dejoy workplace self-protective behavior. Conclusively, the identified association between workplace conditions, blood lead levels, education attainment, knowledge, perceived risk of lead poisoning, and safety practices status of battery technicians fit into Dejoy workplace self-protective theory. Finally, the battery technician's years of experience and gender do not fit into the Dejoy theory of workplace self-protective behavior.

Limitations of the Study

The source of the data gathered for this study were primarily fromself-report of demographic and occupational characteristics, safety practices history, PPEutilization history, and battery technicians' perception of risk associated with lead poisoning in the workplace. The self-report is prone to recall bias as it may be difficult for battery technicians to remember past safety practices correctly. Battery technicians who participated in this study might have provided an answer to the questions, based on what is socially acceptable and thiscould have introduced information bias into the study. This kind of situation could result in either underestimation or overestimation of effects. For a battery technician to report past events correctly, it could depend on their perception of such past event.

Apparently and sentiment apart, it is not likely that all the participants could remember accurately their past safety practices on lead poisoning at the workplace. It is also possible for battery technicians not to know precisely their rate of utilization of PPE and their safety practices status. Furthermore, theresponses used for measuring safety practices, utilization of PPE and battery technician's knowledge of the importance of safety practices on lead poisoning werescored.

The response was scaled from 0-1 using Guttman scale of response. The response was coded in which "1" stand for a correct answers while "0" stand for the wrong answer. The method of scoring adopted for the level of safety practices on lead poisoning was that participants who scored 9 points and above out of 13 questions on safety practices section got (> 70%), and were rated to have good safety practice on lead poisoning, while participant's who scored < 6 points got (< 50%) out of the questions on safety practices were rated to havepoor safety practices on lead poisoning at the workplace. The standard for determination of code "0" and "1" could be high to exclude few weak probable positive responses. All these factors could limit the generalizability of the findings of this study to the entire population of battery technicians in Nigeria. Conclusively, and notwithstanding this shortcoming, the validity, and reliability of the instrument used for this study was established, and battery technician's recall was a reliable measure of safety practices at the workplace (Kalahasthi et al., 2016).

Recommendations

There is a realization that battery technicians safety practices status is positively associated with the workplace conditions, self-protective behavior, and utilization of PPE at the workplace. It is imperative to recommend thus: there should be a provision of hand washing stand with soap and water provided, and it should be well utilized for regular hands and face washing at the workplace of battery technicians' to protectthem against ingestion of lead contaminants. Similarly, the outcome of this study indicated nonavailability of PPE at the battery technicians'workshop. It is recommended that use of PPE like respirator and nose mask could be made compulsory in the workplace for protection against inhalation of lead fumes. The inabilities of battery technicians to install ventilator at the workplace could be substituted withthe use of respirator, and nose mask which are simple, portable, and affordable considering the low monthly income of the battery technicians who participated in this study.

Furthermore, use of overall protective cloth could be made compulsory while in the workplace to protect dermal absorption of lead contaminants, it is not expensive and could be affordable for battery technicians. The outcome of this study on the rate of utilization of PPE at the workplace revealed poor performance of 18%, below average. It is recommended that occupational health and safety inspectorate units could strategize and plan regular monitoring and enforcement of social policy at the workplace of battery technicians. In addition, the battery technician local association could constitute a monitoring committee that could pay regular unscheduled inspection to the battery technician workplace, and enforce use of the required PPE. The stakeholders and government could partner with battery technicians association in Nigeria to work out a safety program that could be directed towards reduction of occupational diseases associated with lead poisoning which is preventable.

The outcome of this study on workplace conditions, utilization of PPE, and safety practices status is related to the result of other studies with similar dependent variable. It is recommended that further studies on safety practices at the workplace of battery technicians is required to disregard or confirm the results of this study conducted in Lagos, Nigeria. Utilization of PPE at the workplace of battery technicians' is a cardinal expectation of safety practices because it could be used to evaluate safety program performance and sustenance. Also, the findings of this study revealed that battery technician education attainment and improvement on the rate of utilization of PPEat the workplace could drive the battery technicians' safety practices status. Finally, it is absolutely important to investigate factors that could influence the rate utilization of PPE at the workplace of battery technicians'especially among the less educated, and illiterate.

Implications of the Study

As a result of extensive literature search before the onset of this study, it was identified that gap do exists in the knowledge of safety practices on lead poisoning among battery technicians in Nigeria. This is the first population based cross-sectional survey on impacts of multilevel factors on safety practices on lead poisoning at the workplace of battery technicians in Lagos. This study outcome could play a major role in planning, implementation, evaluation and sustenance of lead poisoning occupational safety program in Lagos, and other countries with similar occupational safety characteristics as in Nigeria. Considering the outcome of this study, it is evident that safety practices status on lead poisoning among battery technicians in Lagos, Nigeria remains low (20%) which is below average performance. This is the backdrop of the recommendation of Occupational Health Safety and Practice of 90% safety performance at the organization and individual level to avoid occupationally related diseases which were associated with long-term exposure to lead intoxicants.

The outcome of this study proffered much expected alternative approaches of improvement of safety practices status of battery technicians at the workplace. This includes provision of washing stand at the workplace with soap and water provided for washing of hands and faces (personal hygiene) for protection against ingestion of lead contaminants. Also, use of simple PPE like respirator and nose mask to protect against inhalation of lead fumes, and regular wearing of overall protective cloth for protection against dermal absorption since these are the three major routes of contact of lead particles at the workplace.

This approach is less expensive compared to engineering control method, and it could reduce public health burden due to lead poisoning related diseases that are preventable with personal hygiene and use of PPE in, Lagos, Nigeria. The finding of this study has implication for urgent need to influence battery technician’s utilization of PPE with the objective of improving their safety practices status on lead poisoning at the workplace. It implies that effort could be made to encourage use of PPE and make workplace conditions friendly to stimulate and sustain safety practices on lead poisoning at the workplace of battery technicians.

Findings have shown that the rate of utilization of PPE reported is low (18%). Consequently, battery technicians self-report of PPE usage history becomes central to the measurement of lead poisoning safety practices. The recall bias could trail the consideration for this measurement approach. Probabily as a result of the inabilities of battery technicians to remember correctly, then the rate of utilization of PPE centers on factors that influence self-protective behavior. It is sensible to invest in PPE and training on how to use themas this could improve battery technician's safety practices status on lead poisoning at the workplace.

Conclusively, acquisition, training, and utilization of PPE demand enforcement and regular monitoring by the Lagos state Safety Commission. Furthermore, integrated safety practices information and or education program on lead poisoning targeted low level educated battery techniciansis imperative. This recommendation is made against the study findings that revealed association between battery technician's educational attainment, knowledge of the importance of safety practices, perceived risk, and utilization of PPE at the workplace, and subsequently improve safety practices on lead poisoning.

Implications for Positive Social Change

This study positive social change implications relate to the knowledge of the revealed association between battery technicians workplace conditions, perceived risk, utilization of PPE, and safety practices status. The occupational health and safety policy makers could now consider battery technicians workplace conditions, perceived risk and utilization of PPE as a critical component of safety program. Similarly, the federal government of Nigeria and the inspectorate unit of occupation health and safety agency, and the funding partners could now understand the significance of multilevel factors in the realization of occupational lead poisoning safety practices objectives.

The occupational safety inspectorate units, public health professionals, health educators and other stakeholders need to influence battery technician’s safety practices on lead poisoning by encouraging use of PPE at the workplace. In this regard, safety program could be designed and implemented for this purpose. This could stimulate battery technicians’ utilization of PPE at the workplace and cause an increase in safety practices status which is presently low 18%, below average in Lagos. The resultant increase in the rate of utilization of PPE at the workplace could improve battery technician’s safety practices status and reduce the morbidity, disabilities, and mortality that were due to lead poisoning related diseases in Lagos, Nigeria.

Conclusions

Maintaining due diligence on safety practices to guide against lead poisoning at the workplace of battery technicians is acknowledged as the most cost-effective interventions against lead-related diseases. The outcome of this study indicated poor safety practices status of (20%) and the rate of utilization of PPE is (18%) on lead poisoning among battery technicians in Lagos, Nigeria, below average. This study outcome is consistent with the findings of other studies conducted in the developing countries (Ibeh et al., 2016; Kalahasthi et al., 2016; Monney et al., 2014) in which automobile technicians safety practices status and rate of utilization of PPEat the workplace were below average performance.

The outcome of this study had shown that battery technicians' rate of utilization PPE predicts safety practices status. Similarly, the study finding also shows that battery technician's knowledge of the importance of safety practices and education levels were predictors of safety practices status. Furthermore, comparing the rate of utilization of PPE as a result of perceived risk of lead poisoning, the outcome of the study shows that there is no difference in the rate of utilization of PPE by the battery technicians in the organized and roadside setting.

There is a need for researcher to investigate safety practices multilevel factors that influence battery technician's rate of utilization of PPE at the workplace in Lagos, Nigeria. The outcome of such study might identify systemic factors that could be given more attention by the occupational public health professionals, health educators, and policymakers to improve safety practices status of battery technicians at the workplace.

Since battery technician’s knowledge and educational attainment drive the rate of utilization of PPE, then an effort to improve safety practices could be directed towards the training of illiterate and less educated battery technicians on the use of PPE at the workplace.

Further study should be conducted to find out what couldbe done to enable battery technicians comply with the regular and proper use of PPE at the workplace. Lead safety initiative program could be planned, implemented, and evaluation focuses on the contextual view of the Dejoy workplace self-protective model. The lead safety initiative programcould be designed to address the interaction between multilevel factors of intrapersonal, interpersonal, self-protective behavioral factor, physical environment, community and social policy factors.

Conclusively, the findings of this study have demonstrated that it is imperative to develop and launch “Lead Poisoning Safety Initiative” program in Nigeria. The objectiveof this initiative is to improve safety practices status of workers that are occupationally expose to lead poisoning, with emphasis on provision and training on utilization of PPE at the workplace since engineering and ventilation control method are not within the reach of the low-income,resource limited self-employed occupationally lead exposed batterytechnicians in Nigeria.

References

Abdulsalam, S., Onajole, A., Odeyemi, K., Ogunowo, B., & Abdussalam, I. (2015). Comparative assessment of blood lead levels of automobile technicians in organized and roadside garages in Lagos, Nigeria. *Journal of Environmental and Public Health*, *2*(7), 1-9.http://dx.doi.org/10.1155/2015/976563

Adebola, J.O. (2014). Knowledge, attitude and compliance with occupational health and safety practices among pipeline products and marketing company (PPMC) staff in Lagos. *Merit Research Journal of Medicine and Medical Sciences*, *2*(8), 158-173. Retrieved from http://www.meritresearchjournals.org

Adedara, I. A., Ebokaiwe, A.E., & Farombi, E.O. (2013). Tissue distribution of heavy metals and erythrocytes antioxidant status in rats exposed to Nigerian bonny light crude oil. *Journal of Toxicology and Health*, *29*, 162-168.doi:10.1177/0748233711427049

Adela, Y., Ambelu, A., & Tessema, D.A. (2012). Occupational lead exposure among automotive garage workers-A case study for Jimma Town, Ethiopia. *Journal of Occupational Medicine and Toxicology*, *7*(1), 1-15.doi:10.1186/1745-6673-7-15

Ahmad, S.A., Khan, M.H., Khandker, S., Sarwar, A.F., Yasmin, N., Faruquee, M.H., et al. (2014). Blood lead levels and health problems of lead acid battery workers in Bangladesh. *TheScientific World Journal*, 2014(2014), 1-7. http://dx.doi.org/10.1155/2014/974104

Ajayi, O. M., Ajayi, O. M., & Odusanya, A.E. (2014). A review paper on lead exposure and poisoning in Nigeria children: The way forward. *Elixir International Journal,* Retrieved from http:www.elixir.pollution 70(2014) 23808-23811

Ajugwo, A.O., Adias, T.C., Aghatise, K., Fadairo, J.K., & Nyenke, C.U. (2014). Reduced haematological indices in auto-mechanics and fuel attendants in Elele Nigeria. *American Journal of Medical and Biological Research*, *2*(1), 1-4.doi.10.1110.11694/pamj.supp.2014.18.1.4264

Ajumobi, O.O., Tsofo, A., Yango, M., Aworh, M.K., Anagbogu, I. N., Mohammed, A., …Nsubuga, P. (2014). High concentration of blood lead levels among young children in BagegaCommunity, Zamfara – Nigeria and the potential risk factor. *Pan African Medical Journal*, *18*(1), 1-4. doi:10.11694/pamj.supp.2014.18.1.4264

Akintola, A. (2015). *Developing theoretical and conceptual frameworks*. EDMIC Research Workshop, OAU, Ile-Ife, Nigeria; Paper presentedat University of Central Lancashire, Preston, UK: 1-8. Retrieved from http://jedm.oauife.edu.ng

Alberta Occupational Health and Safety Bulletin. (2013). Retrieved from https://work.alberta.ca/occupational-health-safety/ohs-publications.html

American Academy of Pediatrics. (2013). Core clinical service guidelines for the blood lead levels (BLLs) assessment, 1-11. Retrieved from http://passporthealthplan.com/wp-content/uploads/2014/11/leadjuly2013.pdf

Association of Occupational and Environmental Clinics. (2013). Medical management guidelines for lead exposed adults. 16-17. Retrieved from http://www.aoec.org/documents/positions/mmg_revision_with_cste_2013.pdf

Bakulski, K.M., Park, S.K., Weisskopf, M.G., Tucker, K.L., Sparrow, D., Spiro, A., …Weuve, J. (2014). Lead exposure, B vitamins, and plasma homocysteine in men 55 years of age and older: The VA normative aging study. *Environmental Health Perspective Journal*, *122*(10), 1066-1074. doi: 10.1289/ehp.1306931

Bockelmann, I., Pfister, E., &Darius, S. (2011). Early effects of long- term neurotoxic lead exposure in copper worksemployees. *Journal of Toxicology,* 1-11.http://doi.org/1155/2011/832519

California Department of Public Health. (2014). Occupational lead poisoning prevention program (OLPPP) publications.Retrieved from https://archive.cdph.ca.gov/programs/olppp/Documents/LeadHazAlert.pdf

Center for Disease Control and Prevention. (2014). Health problem caused by exposure to lead. Retrieved from https://www.cdc.gov/niosh/topics/lead/health.htm

CDC. (2016). Case definition for lead: Nationally notifiable conditions. Atlanta, GA: Centers for Disease Control andPrevention. Retrieved from https://wwwn.cdc.gov/nndss/conditions/lead-elevated-blood-levels/case-definition/2016/

Creswell, J. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (Laureate Education, Inc., Custom Ed.). Thousand Oaks, CA: Sage Publications. 132-144.

Dejoy, D.M. (1996). Theoretical model of health behavior and workplace self-protective behavior. *Journal of Safety Research, 27*(2), 61–72. Retrieved from http://158.132.155.107/posh97/private/behavioral-safety/theoretical-models-DeJoy.pdf

Dongre, N.N., Suryakar, A.N., Patil, A.J., Amekar, J.G., & Rathi, D.B. (2011). Biochemial effects of lead exposure on systolic &diastolic blood pressure,heme biosynthesis and hematological parameter in automobile workers of north Karnataka(India). *India Journal of clinical Biochem, 26*(4), 400-406. doi:10.1007/s12291-011-0159-6

Dooyema, C.A., Neri, A., Lo, Y.C., Durant, J., Dargan, P.I., Swarthout, T., … Brown, M.J. (2012). Outbreak of fatal childhood lead poisoning related to artisanal gold mining in northwestern Nigeria. *Environmental Health Perspectives Journal, 120*(4), 601-607. doi:10.1289/ehp.1103965

Field, A. (2013). *Discovering statistics using IBM SPSSstatistics.* (4th Ed.). London: Sage.

Gottesfeld, P., & Pokhrel, A.K. (2011). Review: Lead exposure in battery manufacturing and recycling in developing countries and among children in nearby communities. *Journal of Occupational Environmental Hygiene, 8*(9), 520-32. doi:10.1080/15459624.2011.601710

Getaneh, Z., Mekonen, S., &Ambelu, A. (2014). Exposure and health risk assessment of lead in communities of Jimma town, southwestern Ethiopia. *Bulletin of Environmental Contamination and Toxicology*, *93*(2), 245-253. doi:10.1007/s00128-014-1293-7

G* Power software analysis: statistical power test for independent variables.

Hanna-Attisha, M., LaChance, J., Sadler, R.C. & Schnepp, A.C. (2016). Elevated blood lead levels in children associated with the Flint drinking water crisis: A spatial analysis of risk and public health response. *American Journal of Public Health.106*(2), 283-290. doi:10.2105/AJPH.2015.303003.

Haider, M.J., & Qureshi, N. (2013). Studies of battery repair and recycling workers occupationally exposed to lead in Karachi. *National Institute of Public Health*, *64*(1), 37-42.PMID:23789311[PubMed - indexed for MEDLINE]

Hess, C.A., Cooper, M.J., Smith, M.J., Trueman, C.N., & Schutkowski, H. (2013).Lead exposure in adult males in urban transvaal province, South Africa, during theapartheid era. PLoS ONE *8*(3), e58146. doi:10.1371/journal.pone.0058146.

Health Canada.(2013). Risk management strategy for lead. Retrieved fromhttp://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/prms_lead-psgr_plomb/index-eng.php

Huang, W., Lin, J., Lin-tan, D., Hsu, C., Chen, K., &Yen, T. (2013). Environmental lead exposure accelerates progressive diabetic nephropathy in type II diabetic patients. *Biomed Research International Journal,* 1-9. http://dx.doi.org/10.1155/2013/742545

Ibeh, N., Aneke, J., Okocha, C., Okeke, C. &Nwachukwuma, J. (2016).The Influence of occupational lead exposure on haematological indices among petrol station attendants and automobile mechanics in Nnewi, southeast, Nigeria. *Journal of Environmental and Occupational Science*, *5* (1), 1-6. doi: 10.5455/joes.20160320022500

International Labor Organization. (2012). Promoting jobs, protecting people; Occupational safety and health. Retrieved from http://www.ilo.org/global/topics/safety-and-health-at-work/lang--en/index.htm

Iyeonigba, A.O. (2012). Effect of health education on the knowledge and safety practices of auto mechanics in Lagos State [Fellow Medical College, Public Health Dissertation]; National Postgraduate Medical College of Nigeria.

Jangid, A.P., John, P.J., Yadav, D., Mishra, S., & sharma. (2012). Impact of chronic lead exposure on selected biological markers. *India Journal of Clinical Biochemistry*, *27* (1), 83-89. doi:10.1007/512291-011-0163

Ji, J.S., Power, M.C.,Spamors, D., Spirolll, A., Hu, H., Louis. E.D., & Weisskopf, M.G. (2015). Lead exposure and tremor among older men; the VA normative aging Study. *Environmental Health Perspective Journal, 123*(5), 445-450. http://dx.doi.org/10.1289/ehp.1408535

Kalahasthi, R., Barman, T., &Rao, H.R. (2012).Assessment of the relationship between blood lead levels and hematological parameters among lead acid –storage battery plant workers. *Journal of Occupational Environmental Science, 1*(1), 1-5. doi:10.5455/joes/20120602121627

Kalahasthi, R., Barman, T., HR, R., Bagepally, B. S. &Beerappa, R. (2016). Effectiveness of interventions on biological monitoring among workers exposed to Pb from lead-acid Storage battery plant. *International Journal of Medical Science and Public Health, 1*(09), 1-5. doi:10.5455/ijmsph.2016.19112015318

Kasperozyk, S., Blasczyk, I., Dobrakowski, M., Romuk, E., Kaepka-Skrzypczak, L., Adamek, M., &Birkner, E.(2013). Exposure to lead affects male biothiols metabolism. *Annals of Agriculural and Environmental Medicine, 20*(4), 721-725. Retrieved from http://www.aaem.pl/Exposure-to-lead-affects-male-biothiols-metabolism,72005,0,2.html

Khan, D.A., Ansari, W.M., Khan, F.A. (2011). Synergistic effects of iron deficiency and lead exposure on blood lead levels in children. *World Journal of Pediatrics, 7*(2), 150-4. doi: 10.1007/s12519-011-0257-9

Kim, S.A., Oh, H.S., Suh, Y.O., &Seo, W.S. (2014). An integrative model of workplace self-protective behavior for Korean nurses. *Journal of Asian Nursing Research*, *8*(2), 91-98. http://dx.doi.org/10.1016/j.anr.2014.05.003

Kuijp, T.J., Huang, L., & Cherry, C.R. (2013). Health hazards of China's lead-acid battery industry: A review of its market drivers, production processes, and health impacts. *Environmental Health Journal, 12*(61), 1-10. doi**:** 10.1186/1476-069X-12-61

LaBreche, H.G., Meadows, S.K., Nevins, J.R., & Chute, J. P. (2011). Peripheral blood signatures of lead exposure.PLoS ONE, *6*(8), e23043. doi:10.1371/journal.pone.0023043.

LaMorte, W.W. (2016). Power and sample size determination: sample size for one sample, dichotomous outcome. Boston university school of public health. Retrieved from http://sphweb.bumc.bu.edu/otlt/mph-modules/bs/bs704_power/BS704_Power4.html

Levesque, D., Arif, A., & Shen, J. (2012).Association between workplace and housing conditions and use of pesticide safety practices and personal protective equipment among North Carolina farmworkers in 2010. *International Journal of Occupational and Environmental Medicine*, 3, 53-67.Retrieved from http://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=1007&context=shs_pubs

Liao, L.M., Friesen, M.C., Xiang, Y., Cai, H., Koh, D., Ji, B.,…Purdue, M.P. (2016). Occupational lead exposure and associations with selected cancers: the Shanghai men's and women's health study cohorts. *Environmental Health Perspective, 124*(1), 97-103. doi:10.1289/ehp.1408171

Liu, W., Chen, L., & Tian, J. (2016). Uncovering the evolution of lead in-use stocks in lead-Acid batteries and the impact on future lead metabolism in China. *Journal of Environmental Science Technology*, 50 (10), 5412–5419. doi**:** 10.1021/acs.est.6b00775

Margaret, E. S. (2013). "Chelation: harnessing and enhancing heavy metal detoxification-areview." *Scientific World Journal*, Article ID 219840, 1-13. http://de.doi:10.1155/2013/219840

Mason, L.H., Harp, J.P., & Han, D.Y. (2014). Pb neurotoxicity: neuropsychological effects of lead toxicity. *Biomed Research International*, 1-8. http://de.doi.org/10.1155/2015/840547

Monney, I., Bismark, D., Isaac, O., & Kuffour, R.A. (2014). Occupational health and safety practices among vehicle repair artisans in an urban area in Ghana. *Journal of Environmental and Occupational Science*, 1-8. doi:10.5455/jeos.20140528072614

National Institute for Occupational Safety and Health. (2015). Reference blood lead levels (BLL) for adults in the U.S. Retrieved from https://www.cdc.gov/niosh/topics/ables/pdfs/Reference%20Blood%20Levels%20for%20Adults-2015-12-18_508.pdf

Nulhakiem, L. (2013). Hazard control methods. Retrieved from http://safetyandhealth.ufcw.org/committeeguide/controls/

Occupational Health Services and Practice (2013).Retrieved from http://www.ilocis.org/documents/chpt16e.htm

Opeifa, K. (2013). Lagos ttate ministry of transport: 2013-2015 medium-term sector strategy (MTSS). Retrieved from http://www.sparc-nigeria.com/RC/files/1.2.9_Lagos_MTSSs_Review.pdf

Odesanyaolu, A.O. (2011). The effect of intervention on the knowledge and perception of and practice against occupational hazards among automobile mechanics in two local government areas of Ibadan, Oyo state, Nigeria [Fellow Medical College of Public Health Dissertation], NationalPostgraduateMedicalCollegeofNigeria.

Patil, A.J., Bhagwat, V.R., Patil, J.A., Dongre, N.N., Ambekar, J.G., & Kusal, K. (2013). Biochemical aspects of lead exposure and toxicity in spray paintersof western Maharashtra (India).*Journal of Environmental Health Research, 6*(2), 101-110. Retrieved from https://www.researchgate.net/profile/Vinod_Bhagwat/publication/235326905

Peduzzi, P., Concato, J., Kemper, E., Holford, T.R., & Feinstein, A.R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology*, *49*(12), 1373-1379. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/8970487

Perry, G., & Amod, K.P. (2011). Review oflead exposure in battery manufacturing and recycling in developing countries and among children in nearby communities. *Journal of Occupational and Environmental Hygiene*, *8*(9), 520-532. doi: 10.1080/15459624.2011.601710

Pogacean, O.A., & Pop, C. (2015). Potential hand – to – mouth exposure to lead in a car battery factory. *Wulfenia Journal Austria, 22*(5), 83-90. Retrieved from http://www.researchgate.net/publication/275962767

Pogacean, O. A., & Gurzau, E.S. (2014). Workers exposure and individual behavior in a car battery plant. *Indian Journal of Research*, *3*(11), 73-75. doi: 10.15373/22501991/November2014/27

Pottier, G., Viau, M., Ricoul, M., Shim, G.,Bellamy, M., et al. (2013). Lead exposure induces telomere instability in human cells. PLoS ONE *8*(6): e67501.doi:10.1371/journal.pone.0067501.

Rentschler, G., Broberg, K., Lundh, T., & Skerfving, S. (2012). Long-term lead elimination from plasma and whole blood after poisoning. *International Archieve of Occupational and Environmental Health*, *85*(3), 311-316. doi:10.1007/s00420-011-0673-0

Riva, M.A., Lafranconi, A., D'orso, M.I., &Cesana, G. (2012). Lead poisoning: historical aspects of a paradigmatic "occupational and environmental disease"; Research centre on public health, University of Milano Bicocca, Monza, Italy. *Safety Health Workers Journal*, (3), 11-6. http://dx.doi.org/10.5491/SHAW.2012.3.1.11

Rogers, M.L., Lucht, J.A., Sylvaria, A.J., Cigna, J., Vanderslice, R., & Vivier, P.M. (2014). Primary prevention of lead poisoning: protecting children from unsafe housing. *American Journal of Public Health, 104*(8), e119-24. doi: 10.2105/AJPH.2014.301908

Rudestam, K. E., & Newton, R. R. (2015). *Surviving your dissertation: A comprehensive guide to content and process*. (4th Ed.). Thousand Oaks, CA: Sage Publications.

Sharma, S., Sharma, V., Paliwal, R., & Pracheta, S. (2011a). Lead toxicity, oxidative damage and health implications. A review.*International. Journal for Biotechnology & Molecular Biology Research, 2*(13), 215-221. doi: 10.5897/IJBMBRX11.002

Shark, A.P., Sultana, S.A., & Alsaeed, A.H. (2014). Lead exposure: a summary of global studies and the need for new studies from Saudi Arabia. *Hindawi Publishing Cooperation Disease Marker,* 1-7.http://dx.doi.org/10.1155/2014/415160

Simo˜es, M. R., Ribeiro Ju´nior, R. F., Vescovi, M.V.A., de Jesus, H.C.,…Padilha, A.S. et al. (2011). Acute lead exposure increases arterial pressure: role of the renin-angiotensin system. PLoS ONE *6*(4): e18730. doi:10.1371/journal.pone.0018730.

Singh, Z., Chadha, P., & Sharma, S. (2013). Evaluation of oxidative stress and genotoxicity in battery manufacturing workers occupationally exposed to lead. *Toxicology International Journal*, 20(1), 95-100. doi: 10.4103/0971-6580.111550

Sirivarasai, J., Wananukul, W., Kaojarern, S., Chanprasertyothin, S., Thongmung, N., Ratanachaiwong, W.,…Sritara, P. (2015). Environmental lead exposure, catalase gene, and markers of antioxidant and oxidative stress relation to hypertension: an analysis based on the EGAT study. *BioMed Research International Journal*, Article ID: 856319, 1-6. http://dx.doi.org/10.1155/2015/856319

Tuakuila, J., Lison, D., Mbuyi, F., Haufroid, V., & Hoet, P. (2013). Elevated blood lead levels and sources of exposure in the population of Kinshasa, the capital of the Democratic Republic of Congo. *Journal of Exposure Science and Environmental Epidemiology, 23*, 81-87. doi:10.1038/jes.2012.49.

Udiba, U.U., Bashir, I., Akpan, N.S., Olaoye, S., Idio, U. I., Odeke, …Agboun, T. D. T. (2013). Impact of mining activities on ground water quality status, Dareta village, Zamfara, Nigeria.*Archives of Applied Science Research*, *5* (1), 151-158. Retrieved from http://www.scholarsresearchlibrary.com/articles/impact-of-mining-activities-on-ground-water-quality-status-dareta-village-zamfara-nigeria.pdf

US Centers for Disease Control and Prevention. (2012). Response to advisory committee on childhood lead poisoning prevention recommendations in “low level lead exposure harms children: a renewed call of primary prevention" (June 7, 2012). Retrieved from https://www.cdc.gov/nceh/lead/acclpp/cdc_response_lead_exposure_recs.pdf

Were, F.H., Moturi, M.C., Gottesfeld, P., Wafula, G.A., Kamau, G.N., & Shiundu, P.M. (2014). Lead exposure and blood pressure among workers in diverse industrial plants in Kenya. *Journal of Occupational and Environmental Hygiene*, *11*(11), 706–15. doi: 10.1080/15459624.2014.908258.

WHO/ Lead poisoning and health. (2014). 1-4. Retrieved from http://www.who.int/mediacentre/factsheets/fs379/

Zolaly, M.A., Hanafi, M.I., Shawky, N., el-Harbi, K., & Mohamad, M.A. (2011). Association between blood lead levels and environmental exposure among Saudi school children in certain districts of Al-Madinah.*International Journal of Medicine*, *2012*(5), 355-364. http://doi.org/10.2147/IJGM.S28403

Appendix A: Questionnaire

Please tick the most appropriate response

SECTIONA: Technicians Demographic and Occupational information

1. What is your age? ☐ Less than 20 years ☐ Age 20-29 years ☐ Age 30-39 years ☐ Age 40-49 years ☐ Age 50-59 years ☐ Age 60 and above ☐ I don’t know/Not sure

2. Gender ☐ Male ☐ Female

3. Which one of the following best represents your marital status? ☐ Married ☐ Divorced ☐ Widow ☐ Widower ☐ Separated ☐ Single/Never married

4. What is the highest education level you completed?

☐ No formal education ☐ Elementary/primary school level

☐ Some High school ☐ High school graduate

☐ Some college/Technical school ☐ University/College graduate

5. Where is the current location of your workshop?

☐ Ikeja/Approved mechanic yard (Organized) ☐ Ikeja/along the (Roadside)

☐ Agege/ Approved mechanic yard (Organized) ☐ Agege /along the (Roadside)

6. About how much is your monthly income from working as battery technicians?

☐ Below 20,000 Naira monthly ☐ 21,000- 40,000 Naira monthly

☐ 41,000- 60,000 Naira monthly ☐ 61,000 - 80,000 Naira monthly

☐ Above 81,000 Naira monthly

7. How many years have you been working as a battery charger technicians?

☐ Less than 5years ☐ 5-9years ☐ 10-14 years ☐ 15-19 years ☐ 20years and above

SECTION B: Workplace Conditions

Please tick "YES" or "NO" as response for questions 8 to 21.

S/N	Questions on workplace conditions	YES	NO
8	Is drinking water available in the workplace?		
9	Is soap to wash hands available in the workplace?		
10	Are single use towels available to dry hands and body?		
11	Is water to wash hands available while working in the workplace?		
12	Is washing water separated from drinking water?		
13	Do you have water and a place to shower or bath after work?		
14	Is information about lead poisoning pasted where it could be seen and read?		
15	Does your boss talk to you on the needs to work safely with lead contaminants?		
16	Do you come in contact with lead fume when smelting batterylead cells?		
17	Do you come in contact with lead particles when washing battery cells?		
18	Do you come in contact with lead fume when repairing /smoldering lead cell?		
19	Do you swallow sweat off face while smelting battery lead cells?		
20	Do you breathe in lead fumes in the air while working?		
21	Do you have engineering control/ventilation/administrative control on lead pollutants in your workshop?		

SECTION C: Lead Poisoning Safety Practices

Please tick the most appropriate response for question 22 and YES or NO for questions 23 to 34.

22. Which one of the following best represent your protective practices status against lead poisoning while working in the workplace in the past months?

☐ Always ☐ Usually ☐ Sometimes ☐ No protection ☐ Never

S/N	Questions on lead poisoning safety practices	YES	NO
23	Do you have working/restricted areas in your workshop?		
24	Do you follow directions/signs about keeping out of restricted areas in the workshop?		
25	Do you use vaccum or wet cleaning in your workshop?		
26	Do you eat in your workshop areas daily?		
27	Do you wash your hands before eating/drinking/chewing/smoking/toileting?		
28	Do you wear clothing that protects your body from lead dust/particles?		
29	Do you shower/wash with soap and water, and put on clean cloth after work?		
30	Do you wash work clothes separately from other clothes before wearing them again?		
31	Do you wash your clothes immediately in case lead solution spilled on your body and as soon as possible showering and changing into another clean clothes?		
32	Do you have and followed code of safety practices in your workplace?		
33	Is there any monitoring inspector visiting your workplace in the past months?		
34	Are you aware that exposure to lead dust/fumes in your workplace is dangerous/a risk to your body and health?		

SECTION D: Personal Protective Equipment (PPE)

Please tick "YES" or "NO" as response for questions 35 to 38.

S/N	Questions on personal protective equipment (PPE)	YES	NO
35	Do you have all personal protective equipment (PPE) in your workplace?		
36	Is lack of money responsible for not having all personal protective equipment (PPE) in your workplace?		
37	Do you have regular training on the usage of Personal Protective Equipment in your workplace?		
38	Which of the following personal protective equipment (PPE) do you wear while working in the workshop in the past months? 1. Overall Clothes 2. Hand gloves 3. Respirator 4. Eye goggles 5. Nose Mask 6. Protective Shoe/Boot		

SECTION E: Knowledge of Lead Poisoning Safety

Please tick "YES" or "NO" as response for questions 39 to 44.

S/N	Questions on knowledge of lead poisoning safety	YES	NO
39	The appropriate safety equipment for protection against inhalation of fumes 1. Respirator 2. Ventilator		
40	The reason for wearing respirator/ventilation while smoldering battery lead cell is a prevention from inhaling of lead fumes		
41	The appropriate time to use personal protective equipment (PPE) is regularly		
42	Which are common symptoms of lead poisoning? 1. Fatique 2.Sleep disturbance 3.Abdominal cramp		
43	Which diseases are associated with lead poisoning? 1. Anaemia 2. Hypertension 3. Neuropathy		
44	Choose your blood lead level range 1. $\leq 5\mu g/dL$ 2. $6\mu g/dL$ - $40\mu g/dL$ 3. $41\mu g/dL$- $80\mu g/dL$ 4. $81\mu g/dL$ and above 5. No ideal		

Thank you

Name of Investigator………………………..…Signature/Date…………………...