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(Research Article)

Effects of lead exposure on the lung volume of automobile battery workers in Anambra State

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Abstract

Exposure to a heavy metal such as lead may induce various respiratory symptoms. Even though automobile battery recycling, repairs and lead smelting are common in Anambra State, there is no study on the effects of lead exposure on lung volumes of automobile battery workers in Anambra State of Nigeria. Hence, the need to carry out this research. The aim of this study was to evaluate the effect of lead exposure on the lung volumes of automobile battery workers in Anambra State. Respiratory symptoms were evaluated in a sample of two hundred respondents consisting of one hundred lead exposed workers and one hundred control subjects with similar ages using a pre-tested questionnaire. Height of the participants were measured using meter rule. Pulmonary function tests (PFT) were measured in the test group and in control group using a spirometer. Criterion for statistical significance was $p \leq 0.05$. The result of this study showed a decrease in the mean value of peak expiratory flow (PEFR) in the test sgroup (297.74±81.29L/min) compared to control group (379.93±86.57L/min). This decrease was significant ($p = 0.000$). The results of this study showed that exposure to lead has significant effects on the lung volumes of automobile battery workers in Anambra State. The result of the study revealed that there was a significant positive correlation between height and forced expiratory volume in one second in the test group. Lead exposure may be responsible for respiratory symptoms in automobile battery workers.

Keywords: Lead; Spirometer; Peak expiratory flow rate; Automobile battery workers; Pulmonary function test

1. Introduction

The crust of the earth contains trace amounts of lead (Pb), an element that occurs naturally. Despite some advantageous uses, it can be toxic to both humans and animals and have a negative impact on health U.S EPA [1]. Sources of lead include: gasoline, cars and truck emissions. Another source of lead in the air is from the ore and metals processing, as well as piston-engine aircraft working on leaded aviation fuel. . It is used in a variety of products, including lead-acid batteries for automobiles and energy storage, pigments and paints, solder, ceramic glazes, jewelry, toys, and some cosmetics and traditional remedies. Lead pollution and human exposure can occur as a result of its processing, usage, and disposal WHO [2]. The results of lead acid battery and end-of-life management in Nigeria, according to Ogundele *et al* [3], indicated that the majority of old lead acid batteries end up in dumpsites. This tendency is similar to the battery

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disposal method for discarded rechargeable lamps in Nigeria, where roughly 69 percent of the batteries end up in dumpsites Ogundiran *et al* [4]. Osibanjo and Suleiman, on the other hand, discovered that 90% of the batteries were recycled Osibanjo; Suleiman [5; 6]. According to reports, around 90% of discarded lead acid batteries are recycled for lead Ogundele *et al* [3]. majority of old lead acid batteries end up in dumpsites. This tendency is similar to the battery disposal method for discarded rechargeable lamps in Nigeria, where roughly 69 percent of the batteries end up in dumpsites Ogundiran *et al* [4]. Osibanjo and Suleiman, on the other hand, discovered that 90% of the batteries were recycled (Osibanjo; Suleiman [5; 6]. According to reports, around 90% of discarded lead acid batteries are recycled for lead Ogundele *et al* [3]. Used lead acid batteries are unlikely to remain at Nigerian dumps, according to Osibanjo and Suleiman, because scavengers and others will remove them because they have economic value. Reports from the Institute for Health Metrics and Evaluation (IHME) [7], showed that lead poisoning resulted in 900,000 deaths and 21.7 million years of healthy living lost (disability-adjusted life years, or DALYs) worldwide in 2019. The burden was borne primarily by low- and middle-income countries. Anambra state is among the states in Nigeria where repairs, recycling and dumping of lead acid battery is prominent because the importers, sellers, recyclers and repairers of this product reside mostly in Nnewi, Onitsha, Obosi and other areas of the state. Studies have shown that lead exposure have devastating impacts on children and adults who are exposed to lead as well as the environment where lead smelting, dumping and recycling occur.

If the health impacts of lead exposure on automobile battery workers are not identified, more people are bound to suffer the debilitating impacts of lead exposure over the years. Identifying and addressing this problem will have practical benefits for automobile battery workers and residents of Anambra state and Nigeria at large and contribute to understanding of this widespread phenomenon. Even though automobile battery recycling, repairs and lead smelting are common in Anambra State, there is no study on the effects of lead exposure on lung volumes of automobile battery workers in Anambra State of Nigeria. Hence, the inevitable need to carry out this research study.

This research identified the impacts of exposure to lead on the lung volumes of automobile battery workers.

Aim of the Study

To evaluate the effect of lead exposure on the lung volumes of automobile battery workers in Anambra State.

Objectives

The specific objectives include;

- To measure the peak expiratory flow rate (PEFR) of automobile battery workers exposed to lead in Anambra State.
- To evaluate the effect of lead exposure on the forced expiratory volume in one second (FEV1) of automobile battery workers in Anambra State

2. Methods

2.1. Determination of Study Areas

This study was conducted in the three senatorial zones of Anambra state. Three local government areas (LGA) were randomly selected from each senatorial zone. Two Towns were randomly selected from each LGA. Anambra state is made up of three senatorial zones, namely; Anambra North, Central and South. The three senatorial zones were selected in this study to represent the entire state. A combination of multistage and simple random sampling techniques were used to select the study areas and respondents.

2.2. The Experimental Design

A well-structured and pre-tested questionnaire was used to obtain data on the short and long term signs and symptoms of lead exposure on the test and control groups. Pulmonary function tests (PFT) were conducted in two hundred respondents consisting of one hundred lead exposed automobile battery workers and one hundred control subjects using spirometer. Height of the participants were measured using meter rule.

Table 1 The experimental design

Groups	Number of Respondents	Respondents
Test	One hundred	Automobile battery workers
Control	One hundred	Non-automobile battery workers

2.3. Procedure for Data Collection

The researcher went to different workshops of automobile battery workers and non-automobile battery workers, introduced himself and presented the letter of recommendation from his Supervisor to the participants, along-side the letter of ethical approval from Health Research Committee of Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Amaku, Awka and the Informed Consent Form. The researcher then enlightened them on the purpose of the study, type of intervention, participant selection, voluntary participation, research procedure, risks, benefits, reimbursement and confidentiality. The researcher obtained the consent of the participants. The researcher then administered the questionnaire. A Handheld pre-tested and standardized Digital Spirometer with LCD screen (Type P, Meditech Equipment Co., Ltd, China) was used to perform Pulmonary Function Tests(PFT) for all the participants. Prior to Pulmonary Function Testing, the PFT measurement technique was demonstrated by the researcher, and participants were encouraged and supervised throughout test performance. Pulmonary Function Test was performed using the acceptability standards outlined by the American Thoracic Society (ATS) with participants in an upright sitting position American Thoracic Society [8]. The participants took a deep breathe, placed the mouthpiece of the spirometer in their mouths and covered the mouthpiece with their lips tightly to prevent air leakage and then forcefully expired into the mouthpiece of the spirometer until the air in the lung was fully expired. Pulmonary Function Tests were performed three times in each subject.The highest level for Forced Expiratory Volume in one Second (FEV1), and Peak Expiratory Flow Rate (PEFR) were taken independently from the three measurements. Certificate of participation was issued to the participants.

2.4. Study Population

Two hundred respondents consisting of one hundred lead exposed automobile battery workers between the ages of thirty to thirty-nine years males and one hundred control subjects between the ages of thirty to thirty-nine years males participated in this study.

2.4.1. Inclusion Criteria

- Automobile battery workers with and without signs and symptoms of short and long term exposure to lead.
- Automobile battery workers within the study area.
- Subjects who were not automobile battery workers were used as controls.

2.4.2. Exclusion Criteria

- Automobile battery workers who were not resident within the study areas.

2.5. Duration of the Study

The study was carried out from January to March, 2022.

2.6. Sample Size Determination

The sample size (n) was determined using simple proportion formula Cochran [9].

$$n = \frac{2z^2pq}{d^2}$$

Where;
n = minimum sample size,
Z = standard normal deviate usually set at 1.96 which corresponds to the 95% confidence level.
P = proportion of automobile battery workers in the target population who were exposed to lead. The prevalence rate of lead exposure in adult was 1.9% according to Minnesota Department of Health [10].

Thus, 1.9÷100 = 0.019. q = proportion of persons in the population without factors under study.

Thus q = 1.0 – p = 1- 0.019 = 0.981

d = degree of accuracy desired usually set at 0.05.

Therefore,

$$n = \frac{2 \times 1.96^2 \times 0.019 \times 0.981}{0.05^2}$$

Approximately = 57. Thus, applying expected attrition 10%

57×10/100 ≈ 6. Therefore, 57+6 = 63.

The calculated minimum sample size was 63.

2.7. Sampling Technique

A combination of multistage and simple random sampling techniques were used to carry out this study.

2.8. Statistical Analysis

The data of age, height and PFT values were expressed as mean ± SD and analysis was performed using independent t-test and Pearson's correlation. $P \leq 0.05$ was the criterion for statistical significance. All analyses were performed with SPSS software (version 23). The data obtained were arranged in tables and bar charts on the basis of simple percentage.

3. Results

Table 2 The mean ± SD levels of Age, PEF and FEV1 in Test and Control Groups**.**

Parameters	**Test group**	**Control group**	**t-test**	**p-value**
Age (year) (30-39)	35.69±11.96	33.63±10.79	1.279	0.203
PEFR(L/min)	297.74±81.29	379.93±86.57	-6.921	0.000***
FEV1 (L)	3.80±0.77	3.73±0.63	0.664	0.508

Where

PEFR = Peak Expiratory Flow Rate

FEV1 = Forced Expiratory Volume in one second

value = Level of significance($P \leq 0.05$).

t-test = Independent t-test.

* = Significant.

Table 3 Correlation of height and age with PEF and FEV1 in the test group

Parameter	**r**	**p-value**
Height vs. PEF	0.162	0.107
Height vs. FEV1	0.298	0.003**
Age vs. PEF	-0.448	0.000***
Age vs. FEV1	-0.441	0.000***

Table 4 Correlation of height and age with PEF and FEV1 in the control group

Parameter	r	p-value
Height vs. PEF	-0.067	0.509
Height vs. FEV1	0.606	0.000***
Age vs. PEF	-0.091	0.369
Age vs. FEV1	-0.127	0.209

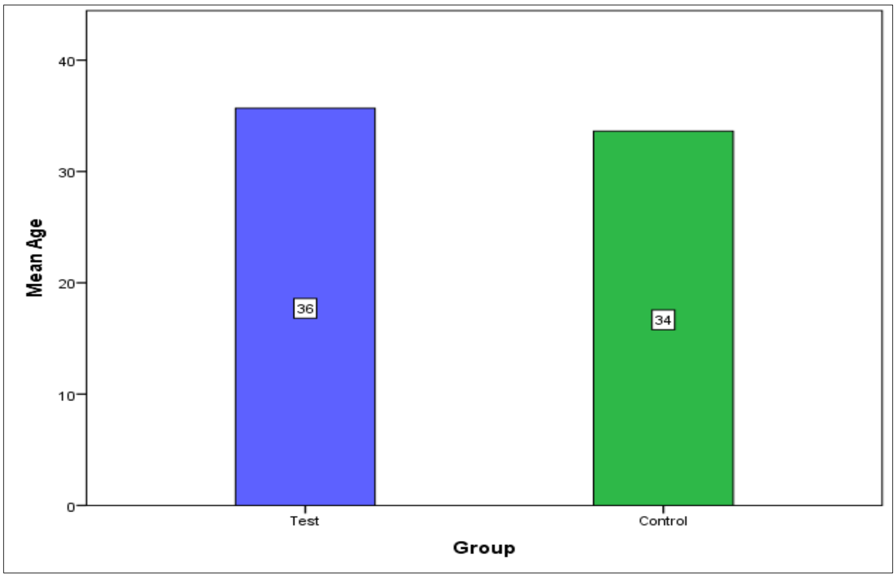

Figure 1 The mean values of the age of the test and control groups

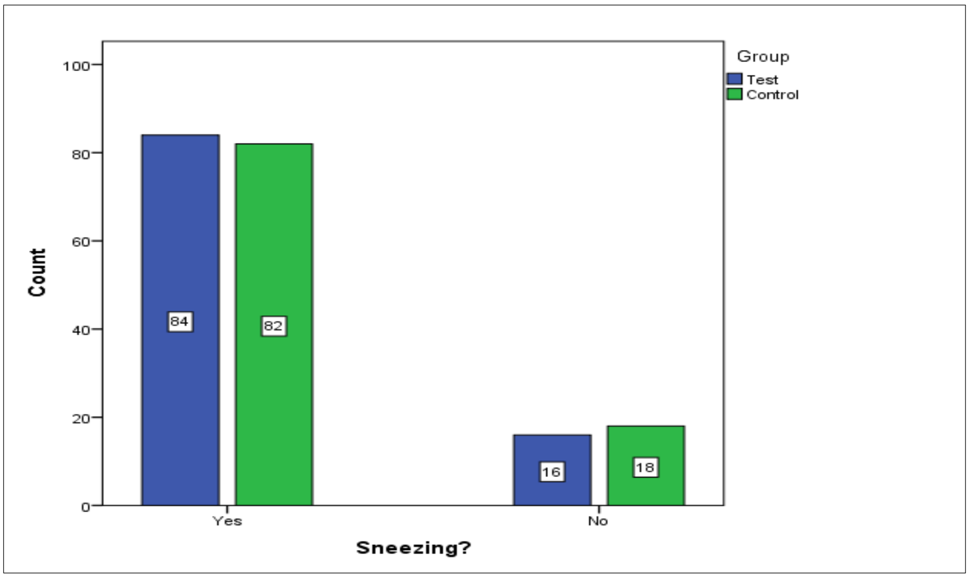

Figure 2 The comparison of the presence of sneezing in test and control groups

4. Discussion

The result of the study showed significant (p=0.000) decrease in the mean value of peak expiratory flow rate (PEFR) in the test group when compared with control group. Decreased peak expiratory flow rate indicates narrowing of larger airways which manifests in form of coughing, feeling tired, feeling short of breath or feeling of chest tightness. The reason for lead exposure having great impact on larger airways may be due to particle size of this heavy metal.This finding is in agreement with observation of Mohammad *et al* [11]. There was an insignificant (p=0.664) increase in the mean value of forced expiratory volume in one second (FEV1) in the test group when compared to control group. The result suggests that lead exposure may likely not have impacts on the forced expiratory volume in one second. This finding is not in agreement with the finding of Mohammad *et al* [11], who reported that lead exposed workers have low FEV1. The disagreement between the result of the present study and that of Mohammad *et al* [11] might be due to the variations in predicted values such as ethnicities, race, gender, age or height of the participants of this study and that of Mohammad *et al* [11].

The result showed an insignificant positive correlation between peak expiratory flow rate and height in the test group. The result of the present study is different from the observation of Archana [12], who reported that peak expiratory flow rate and height have a linear positive correlation with increasing height. Other similar studies have shown that height is one anthropometric variable which is strongly correlated with change in peak expiratory flow rate Seo *et al;* Gundogdu and Eryilmaz; Goswami *et al* [13; 14; 15]. The result of the study revealed that there was a significant positive correlation between height and forced expiratory volume in one second in the test group.Height is a predictor of forced expiratory volume in one second. Tall people have greater lung volume than short people Wun *et al* [16]. The result of the present study showed insignificant negative correlation between age, peak expiratory flow rate and forced expiratory volume in one second in the test group. As age increases, the lung volumes and capacities (FEV1 and PEFR) decrease Oloyede *et al* [17]. This may be likely due to the loss of the natural elasticity of lung tissue as age increases, resulting in reduced lung volumes and capacities. The result of the present study is in support of the report of Mohammad *et al* [11], who observed no significant correlation between age and pulmonary function test values (FEV1 and PEFR). The result showed insignificant negative correlation between height and peak expiratory flow rate (PEFR) in the control group. It has been reported that peak expiratory flow rate is greater in tall people than short people Wun *et al* [16]. Height is one of the predictors of PEFR. There was a significant positive correlation between height and forced expiratory volume in one second. The result indicates that height of an individual is one of the determining factors of FEV1. FEV1 is the amount of air that can be forcibly exhaled in the first second following complete inspiration Perez [18]. The result revealed an insignificant negative correlation between age, FEV1 and PEFR in the control group. The result of the present study is consistent with the report of Mohammad *et al* [11], who observed no significant correlation between age and pulmonary function test values (FEV1 and PEFR).The result showed significant (p=0.000) increase in the presence of coughing in the test group compared to control group. This implies that coughing may be associated with lead exposure. This also suggests that lead exposure induces cough among automobile battery workers. Cough, commonly known as Tussis, is a quick expulsion of air from the lungs and is a voluntary or involuntary act that clears the throat and breathing passage of foreign particles, bacteria, irritants, fluids, and mucus. Although it is seen as the most typical sign of respiratory illnesses, it protects the respiratory system from harmful chemicals and maintains airway patency by clearing excessive secretions from the airways. The result of this study is consistent with the finding of Mohammad *et al* [11] who reported high prevalence in cough among automobile battery workers. There was significant (p=0.005) increase in the rate at which automobile battery workers (test group) sneezed moderately and regularly compared to control group. Increase in the rate of sneezing may be as a result of regular exposure to lead. Secondly, it may be due to development of allergy by the body as a result of constant exposure to lead. Sneezing can be triggered by a variety of things such as allergens and nasal irritants Wint and Fisher [19].

5. Conclusion

The results of this study showed that exposure to lead has significant effects on the lung volumes of automobile battery workers in Anambra State. In addition, lead exposure may cause respiratory symptoms and those affected may be at high risk of developing other respiratory disorders.

Compliance with ethical standards

Acknowledgement

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Disclosure of conflict of interest

There was no conflict of interest.

Statement of ethical approval

Ethical approval was obtained from the Health Research Committee of Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Amaku, with the reference number: COOU/CMAC/ETH.C/VOL.1/FN:04/200. Before commencement of the study, information about the objectives of the study and the role of the participants were provided to the participants. In addition, they were informed that their participation was voluntary and that they could withdraw from the study at any stage without any consequences.

Statement of informed consent

Subsequently, written and signed informed consent was obtained from the participants. Participants who did not consent, or who lacked the mental capacity to consent were ineligible to participate. Participants' confidentiality was kept. All procedures were aligned with recommendations from the Ethics and Regulatory Board of Chukwuemeka Odumegwu Ojukwu University Teaching Hospital Akwa, Anambra State.

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