

## Assessment of the lipid profile levels of lead acid battery factory worker occupationally exposed to heavy metals in Nnewi, Nigeria.

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### Abstract

**Background of study:** Cardiovascular disease (CVD) and environmental degradation are leading global health problems of our time. Recent studies have linked exposure to heavy metals to the risks of CVD and diabetes especially in populations of developing countries like Nigeria. **Materials and methods:** This is a cross-sectional study designed to assess the lipid profile levels of lead acid battery factory workers occupationally exposed to heavy metals in Nnewi, Nigeria. A total of one hundred and seventeen (117) participants comprised of control N (n=39), control E (n=40) and lead acid battery factory workers (V=38) aged between 18 and 56 years were recruited for the study. 5ml of venous blood sample was collected from each individual for the evaluation of Triglyceride (TAG), Total cholesterol (TChol), Low density lipoprotein cholesterol (LDL-C), High density lipoprotein cholesterol (HDL-C) and Very low density lipoprotein cholesterol (VLDL-C) levels using standard laboratory methods.

**Results:** This showed that TAG level for lead acid battery factory workers ( $1.17 \pm 0.06$ ) were significantly reduced ( $p < 0.05$ ) compared with control E ( $1.83 \pm 0.01$ ) participants. Tchol and LDL-C levels were significantly elevated while VLDL-C level was significantly reduced ( $p < 0.05$ ) in factory workers when compared with control participants ( $p < 0.05$ ) respectively. While the HDL-C level of lead acid battery factory workers was elevated ( $p < 0.05$ ) compared with control N ( $1.68 \pm 0.08$  Vs  $1.40 \pm 0.07$ ;  $p < 0.05$ ) participants, it was however, significantly reduced compared with control E participants ( $1.27 \pm 0.11$  Vs  $2.40 \pm 0.02$ ;  $p < 0.05$ ).

**Conclusion:** This study has revealed a possible risk for cardiovascular disease among lead acid battery factory workers in Nnewi, Nigeria and hence calls for urgent attention.

**Keywords:** lead acid battery factory, occupational exposure, lipid profile levels, body mass index, age, length of service (LOS).

### Résumé

**Contexte de l'étude :** Les maladies cardiovasculaires (MCV) et la dégradation de l'environnement sont les principaux problèmes de santé mondiaux de notre époque. Des études récentes ont établi un lien entre l'exposition aux métaux lourds et les risques de maladies cardiovasculaires et de diabète, en particulier dans les populations de pays en voie de développement comme le Nigeria.

**Matériels et méthodes :** Il s'agit d'une étude transversale conçue pour évaluer les niveaux de profil lipidique des travailleurs de l'usine de batteries au plomb-acide exposés professionnellement aux métaux lourds à Nnewi, au Nigeria. Un total de cent dix-sept (117) participants comprenant le contrôle N (n = 39), le contrôle E (n = 40) et les ouvriers de l'usine de batteries au plomb-acide (V = 38) âgés de 18 à 56 ans ont été recrutés pour l'étude. 5 ml d'échantillon de sang veineux ont été prélevés sur chaque individu pour l'évaluation des triglycérides (TAG), du cholestérol total (TChol), du cholestérol des lipoprotéines de basse densité (LDL-C), du cholestérol des lipoprotéines de haute densité (HDL-C) et du cholestérol des lipoprotéines de très basse densité. (VLDL-C) en utilisant des méthodes laboratoire standard.

**Résultats:** Ceci a montré que le niveau de TAG pour les ouvriers de l'usine de batteries au plomb-acide ( $1,17 \pm 0,06$ ) était significativement réduit ( $p < 0,05$ ) par rapport aux participants du groupe témoin E ( $1,83 \pm 0,01$ ). Les niveaux de Tchol et de LDL-C étaient significativement élevés tandis que le niveau de VLDL-C était significativement réduit ( $p < 0,05$ ) chez

les ouvriers d'usine par rapport aux participants témoins ( $p < 0,05$ ) respectivement. Alors que le niveau de HDL-C des ouvriers de l'usine de batteries au plomb-acide était élevé ( $p < 0,05$ ) par rapport aux participants témoins N ( $1,68 \pm 0,08$  Vs  $1,40 \pm 0,07$  ;  $p < 0,05$ ), il était cependant significativement réduit par rapport aux participants témoins E ( $1,27 \pm 0,11$  Vs  $2,40 \pm 0,02$  ;  $p < 0,05$ ).

**Conclusion :** Cette étude a révélé un risque possible de maladie cardiovasculaire chez les travailleurs de l'usine de batteries au plomb-acide à Nnewi, au Nigeria, et appelle donc une attention urgente.

**Mots clés:** Usine de batteries au plomb-acide, exposition professionnelle, taux de profil lipidique, indice de masse corporelle, âge, durée de service (LOS).

### Introduction

Lead is a naturally occurring metal found in the Earth's crust. It is dense, ductile, malleable and corrosion-resistant and these properties have made it useful in building materials, pigments to glaze ceramics, water pipes, glass, paints and protective coatings, acid storage batteries and gasoline additives [1]. In Nigeria, there are numerous small scale and medium scale industries and occupational workers (auto-mechanics, electricians, welders, painters, panel beaters etc.) that use lead-based materials. Some of these industries have no work place regulations for lead exposure. However, the widespread use of lead has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world [2].

According to United States Environmental Protection Agency (USEPA), [3], the natural levels of lead in soil range between 50 and 400 parts per million, but industrial activities such as mining, smelting, and refining activities have resulted in substantial increases in lead levels in the environment, especially near mining and smelting sites. Lead is a heavy metal which is toxic and ubiquitous in nature, and it is regarded as nonessential as it plays no role in the biological system but rather adversely affects various organs in the body in both children and adults. Regrettably, in many developing countries, Nigeria inclusive, occupational exposure to lead is absolutely unregulated and most time unmonitored which may account for increased occupational exposure to this toxic metal [4]. Occupational exposure to lead has been linked to cardiovascular diseases characterized by dyslipidemia [5].

The cardiovascular system consists of the heart and blood vessels [6]. Cardiovascular diseases

are a group of diseases that affect the heart and blood vessels. Cardiovascular diseases which include coronary heart disease and stroke are the most common non-communicable diseases globally, responsible for an estimated 17.8 million deaths in 2017, of which more than three quarters were in low-income and middle-income countries [7]. In Nigeria, CVDs accounted for 11% of all deaths in 2018 [8] (WHO, 2018). Coronary artery disease and stroke account for 80 % of CVD death in males and 75 % of CVD deaths in females [9]. The burden of cardiovascular diseases in developing countries such as Nigeria is worsened by the increasing prevalence of cardiovascular risk factors [10]. CVDs are often characterized by dyslipidemia which is associated with atherosclerosis and increases the risk of cardiovascular disease (CVD). Dyslipidemia can be defined as elevated of plasma levels of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG), as well as lower plasma levels of high-density lipoprotein cholesterol (HDL-C). These increases can occur either singly or in combination [11, 12].

Occupational exposure to chemicals and toxicant from the working environment could pose serious health challenges. Notably, elevated levels of lead have been previously recorded in the present study area in various factories including lead acid battery, cable manufacturing and forging factories [13-15]. Occupational lead exposures have been reportedly said to be the responsible cause of various organ damage including cardiovascular diseases, renal failure, liver damage, cancer, and so on. Lead exposure has been shown to alter lipid metabolism in human [5, 16-18] and animal studies [19]. The alterations in lipid and lipoproteins may contribute to the development and progression of atherosclerosis and cardiovascular diseases. Studies have also reported that exposure to lead induces dyslipidemia thereby resulting in the accumulation of lipids in the walls of blood vessels [20]. In view of this, the present study assessed the lipid profile levels of lead acid battery factory workers occupationally exposed to heavy metals in Nnewi, Nigeria.

### Materials and methods

#### Study design

This is a cross-sectional study designed to assess the lipid profile levels in persons occupationally exposed to heavy metals in lead acid battery factory in Nnewi, Nigeria.

A total of thirty-eight (38) apparently healthy individuals in the exposed group (lead acid battery factory workers) aged between 19 and 56 years were

recruited for the study. The occupationally exposed group comprised workers from lead acid battery factory who were constantly being exposed to effluents from the factory. The control groups were made up of two (2) sets: The first set was made up of thirty-nine (39) staff and undergraduate students of the College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus whose residential homes were at least 5-10 km from the factory sites, while the second set was made up of forty (40) staff and undergraduate students of the Faculty of Medicine, Madonna University, Elele. They were aged between 18 and 44 years. Informed consent was obtained from all individuals after being educated on the benefit of the study and completing of a structured questionnaire. Thereafter, 5ml of venous blood sample was collected from each individual for the evaluation of lipid profile parameters.

#### Inclusion criteria

Apparently healthy individuals aged between 19 and 56 years who are exposed to lead and control individual (non-exposed groups) were included in this study.

#### Exclusion criteria

Individuals of any known cardiovascular disease, diabetes mellitus, kidney disease, alcoholics and smokers as well as those outside the age limits were excluded from the study.

#### Lipid Estimation

Lipid profile levels were determined using enzymatic colorimetric methods. The method for Total Cholesterol was described by Roeschlaw *et al.* [21].

Serum triglyceride was determined by using the method described by Schettler and Nussel [22]. High density lipoprotein was determined using the method described by Assmann [23]. LDL-C and VLDL-c was estimated by calculation according to the formula of Friedewald *et al.* [24].

#### Anthropometrics measurements

Weight and height was measured in clothing without shoes and body mass index (BMI) calculated as:  $BMI = \text{weight (kg)} / \text{height (m}^2\text{)}$ .

Height was obtained with a measuring tape attached to a wood while weight was by use of a manual weighing scale.

#### Ethical consideration

Ethical approval for this study was sought and obtained from Ethical Committee, NnamdiAzikiwe University Teaching Hospital, Nnewi, Anambra State, Nigeria (NAUTH/CS/66/Vol.2/149).

#### Statistical analysis

The data were presented as mean $\pm$ SEM and the mean values of the control and test group were compared by Students t-test and Pearson's bivariate correlation coefficient using Statistical package for social sciences (SPSS) (Version 16) software. A  $P < 0.05$  was considered as significant.

#### Results

Table 1 shows the lipid profiles of both controls N and E participants and lead acid battery factory workers. While the triacylglycerols (TAG), total cholesterol (TChol) and high density lipoprotein – cholesterol (HDL-C) levels of control N participants

**Table 1:** Lipid profile of the factory workers

Factory	TAG (mmol/L)	TChol (mmol/L)	HDL -C (mmol/L)	LDL-C (mmol/L)	VLDL -C (mmol/L)
N(n=39)	1.10 $\pm$ 0.07 <sup>ab</sup>	3.84 $\pm$ 0.22 <sup>ab</sup>	1.40 $\pm$ 0.07 <sup>bc</sup>	1.30 $\pm$ 0.14 <sup>a</sup>	1.19 $\pm$ 0.09 <sup>c</sup>
E(n=40)	1.83 $\pm$ 0. 01 <sup>d</sup>	5.54 $\pm$ 0. 03 <sup>d</sup>	2.40 $\pm$ 0. 02 <sup>e</sup>	1.98 $\pm$ 0. 01 <sup>b</sup>	1.16 $\pm$ 0. 01 <sup>c</sup>
V(n=38)	1.17 $\pm$ 0.06 <sup>ab</sup>	5.17 $\pm$ 0.30 <sup>cd</sup>	1.68 $\pm$ 0.08 <sup>d</sup>	2.77 $\pm$ 0.28 <sup>c</sup>	0.57 $\pm$ 0.03 <sup>b</sup>

Values are in mean ( $\pm$ SEM); within the column, means with different superscripts are statistically significant ( $p < 0.05$ ).

#### KEY

- N::** Control participants from Nnewi  
**E:** Control participants from Elele  
**V:** Workers from lead acid battery factory  
**TAG:** Triacylglycerol  
**TChol:** Total cholesterol  
**HDL-C:** High density lipoprotein cholesterol  
**LDL-C:** Low density lipoprotein cholesterol  
**VLDL-C:** Very low density lipoprotein cholesterol

were significantly decreased ( $p < 0.05$ ) compared to those of control E participants, the low density lipoprotein-cholesterol (LDL-C) and very low density lipoprotein-cholesterol (VLDL-C) levels of control E did not differ significantly ( $p > 0.05$ ) from the control N participants. Figures 1 and 2 present the correlation coefficients of lipid profiles of control N and E participants with BMI. In control N, TAG and VLDL-C were positively correlated while TChol, HDL-C and LDL-C were negatively correlated. However, in control E, TChol, HDL-C and VLDL were positively correlated while TAG and LDL-C were negatively correlated.

The TAG levels for lead acid battery ( $1.17 \pm 0.06$ ) factoryworkers were significantly reduced ( $p < 0.05$ ) compared to control E ( $1.83 \pm 0.01$ ) participants and did not differ significantly when compared to control N participants ( $p > 0.05$ ). Total cholesterol was elevated significantly ( $p < 0.05$ ) in lead acid battery ( $5.17 \pm 0.30$ ) factory workers than in control participants. While the HDL-C level of lead acid battery ( $1.68 \pm 0.08$ ) factory workers was elevated ( $p < 0.05$ ) compared with control N ( $1.40 \pm 0.07$ ) participants, however, the HDL-C levels of lead acid battery ( $1.27 \pm 0.11$ ) factory workers were significantly reduced ( $p < 0.05$ ) compared with

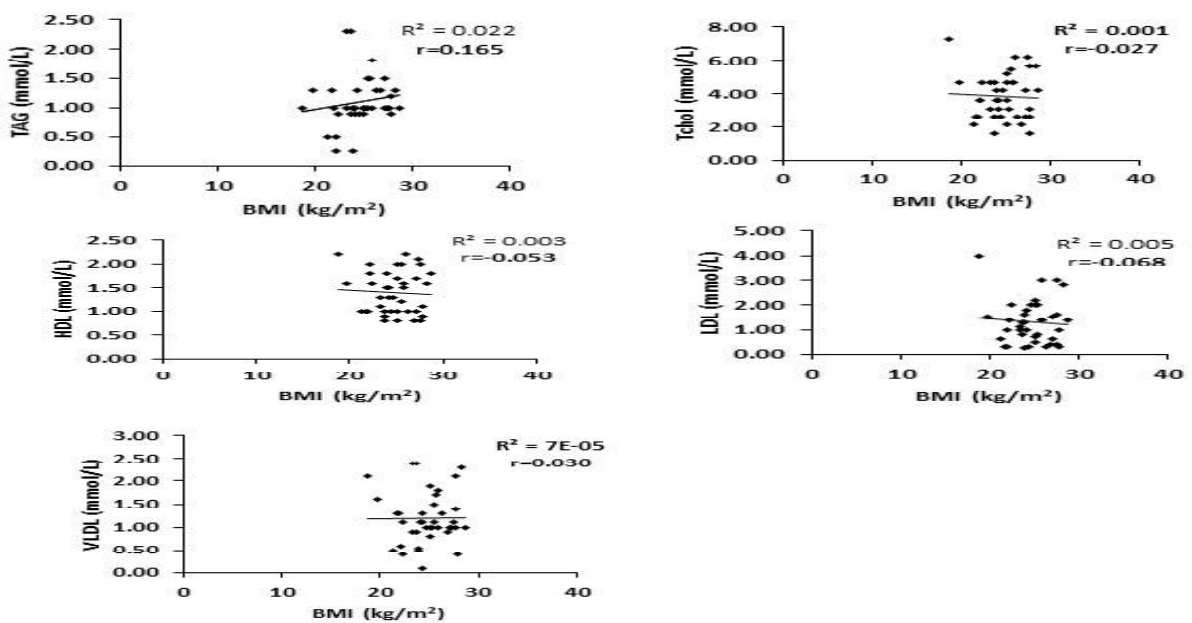


Fig. 1: Regression of lipid profile of control participants with BMI (Nnewi)

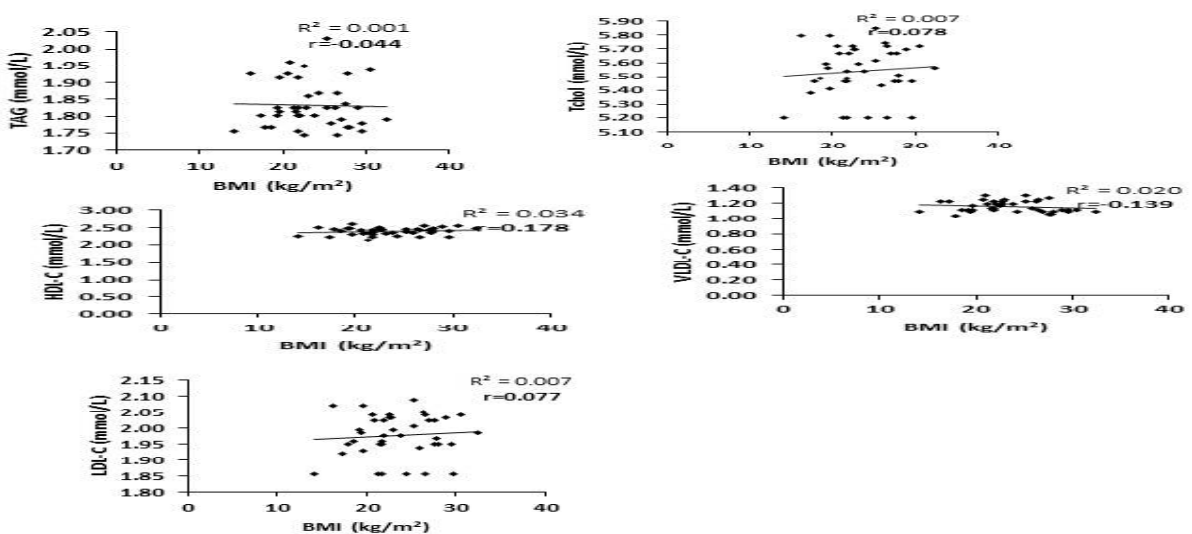


Fig. 2: Regression of lipid profile of control participants with BMI (Elele)

**Table 2:** Effect of age on the lipid profile of lead acid battery factory workers.

Age group	TAG (mmol/L)	TCHOL (mmol/L)	HDL-C (mmol/L)	LDL-C (mmol/L)	VLDL-C (mmol/L)
N(n=39)	1.10±0.07 <sup>a</sup>	3.84±0.22 <sup>a</sup>	1.40±0.07 <sup>a</sup>	1.30±0.14 <sup>a</sup>	1.19±0.09 <sup>b</sup>
18-30yrs (n=25)	1.21±0.08 <sup>a</sup>	5.01±0.33 <sup>ab</sup>	1.60±0.08 <sup>a</sup>	2.82±0.33 <sup>bc</sup>	0.58±0.04 <sup>a</sup>
31-40yrs (n=5)	1.01±0.17 <sup>a</sup>	5.35±0.89 <sup>bc</sup>	1.49±0.21 <sup>a</sup>	3.38±0.87 <sup>c</sup>	0.48±0.08 <sup>a</sup>
41-50yrs (n=4)	1.23±0.15 <sup>a</sup>	4.39±1.20 <sup>ab</sup>	2.33±0.27 <sup>b</sup>	1.84±0.76 <sup>ab</sup>	0.66±0.07 <sup>a</sup>
51-60yrs (n=4)	1.02±0.05 <sup>a</sup>	6.72±0.26 <sup>c</sup>	1.78±0.82 <sup>a</sup>	2.60±0.54 <sup>bc</sup>	0.51±0.03 <sup>a</sup>

Values are in mean ( $\pm$ SEM); within column, means with different superscripts are statistically significant ( $p < 0.05$ )

**KEY:**

**N:** Control participants from Nnewi

**E:** Control participants from Elele

**TAG:** Triacylglycerol

**TChol:** Total cholesterol

**HDL-C:** High density lipoprotein cholesterol

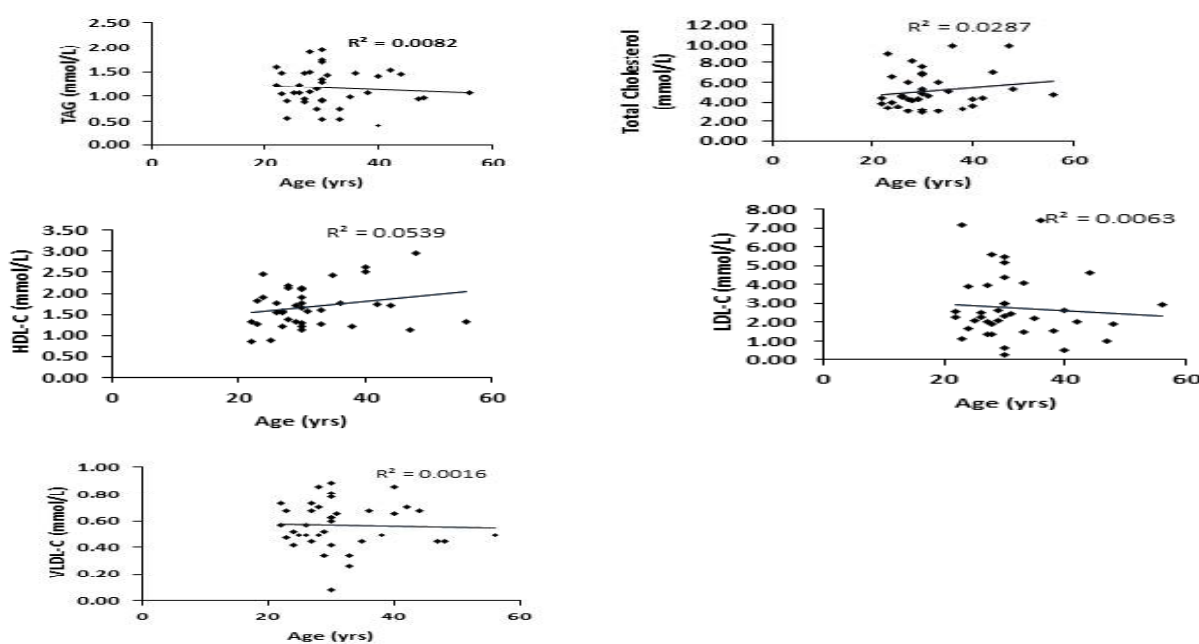
**LDL-C:** Low density lipoprotein cholesterol

**VLDL-C:** Very low density Lipoprotein cholesterol

control E participants. Low density lipoprotein-cholesterol (LDL-C) level of the factory workers were significantly elevated ( $p < 0.05$ ) compared with  $1.30 \pm 0.14$  of control N and  $1.98 \pm 0.01$  of control E participants. The VLDL-C level of the factory workers were significantly reduced ( $p < 0.05$ ) when compared with control N ( $1.19 \pm 0.09$ ) and control E ( $1.16 \pm 0.01$ ).

The result of the effect of age on the lipid profile of lead acid battery factory workers is presented in Table 2 while Figure 3 presents the regression with age. There was no significant

difference ( $p > 0.05$ ) between the lipid parameters of all the age groups and the control N participants except in VLDL-C where there was a significant decrease ( $p < 0.05$ ) in the age groups compared with the control N participants with the lowest in the 51-60yr age group. Except for TChol ( $r = 0.170$ ;  $p = 0.309$ ) and HDL-C ( $r = 0.233$ ;  $p = 0.159$ ) which were positively correlated with age, TAG ( $r = -0.090$ ;  $p = 0.591$ ), LDL ( $r = -0.079$ ;  $p = 0.636$ ) and VLDL ( $r = -0.044$ ;  $p = 0.795$ ) were negatively correlated with age, though none was statistically significant ( $p > 0.05$ ).

**Fig. 3:** Regression of lipid profile of lead acid battery factory workers with age

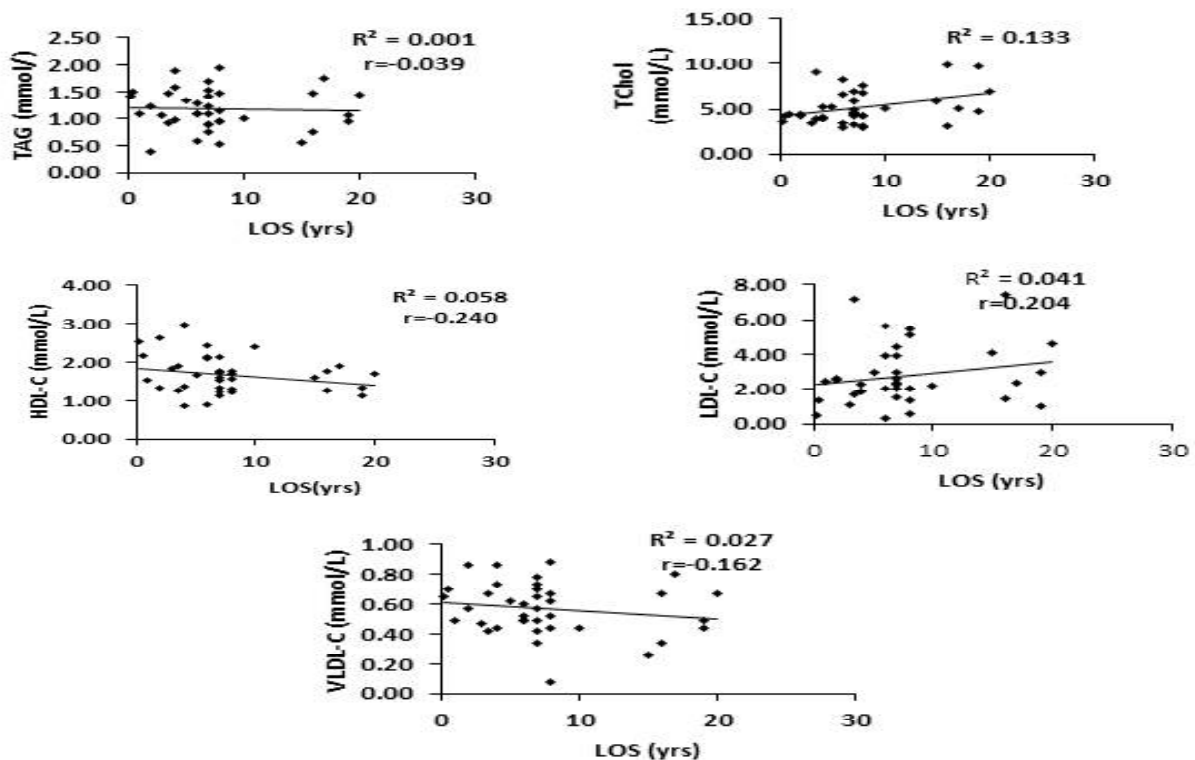
**Table 3:** Effect of LOS on lipid profile of lead acid battery factory workers

LOS group	TAG (mmol/L)	TCHOL (mmol/L)	HDL (mmol/L)	LDL (mmol/L)	VLDL (mmol/L)
N (n=39)	1.10±0.07 <sup>ab</sup>	3.84±0.22 <sup>a</sup>	1.40±0.07 <sup>ab</sup>	1.30±0.14 <sup>a</sup>	1.19±0.09 <sup>a</sup>
0-5yrs(n=25)	1.24±0.12 <sup>b</sup>	4.69±0.43 <sup>ab</sup>	1.84±0.20 <sup>b</sup>	2.38±0.53 <sup>abc</sup>	0.66±0.05 <sup>a</sup>
6-10yrs(n=7)	1.18±0.09 <sup>b</sup>	5.20±0.38 <sup>ab</sup>	1.69±0.11 <sup>b</sup>	3.00±0.36 <sup>bc</sup>	0.55±0.05 <sup>a</sup>
11-15yrs(n=2)	0.74±0.12 <sup>a</sup>	5.49±1.60 <sup>ab</sup>	1.29±0.11 <sup>a</sup>	1.76±0.79 <sup>ab</sup>	0.44±0.07 <sup>b</sup>
16-20yrs(n=4)	1.29±0.18 <sup>b</sup>	5.94±1.16 <sup>b</sup>	1.60±0.13 <sup>ab</sup>	3.75±1.05 <sup>c</sup>	0.60±0.08 <sup>a</sup>

Values are in mean (±SEM); within the same column, means with different superscripts are statistically significant ( $p < 0.05$ );

**KEY:**

**N:** Control participants from Nnewi  
**LOS:** Length of service  
**TAG:** Triacylglycerols  
**TCHOL:** Total cholesterol  
**HDL-C:** High density lipoprotein cholesterol  
**LDL-C:** Low density lipoprotein cholesterol  
**VLDL-C:** Very low density lipoprotein cholesterol

**Fig. 4:** Regression of lipid profile of lead acid battery factory workers with LOS

The effect of LOS on the rheological indices of lead acid battery workers (Table 3) showed that no significant difference was observed between the TAG, HDL-C and VLDL-C levels of control participants and the LOS groups except at the 11-15yrs LOS group, however, TChol was significantly

elevated ( $p < 0.05$ ) in the 16-20 yr group while LDL-C was significantly elevated ( $p < 0.05$ ) in the 6-10 and 16-20 yrs groups. The result of correlation analyses (Figure 4) showed that except for TChol ( $r = 0.365$ ;  $p = 0.024$ ) which was positively correlated significantly ( $p < 0.05$ ) with LOS, LDL-C ( $r = 0.204$ ;

$p=0.220$ ) though positively correlated, was not significant ( $p<0.05$ ) while TAG, HDL-C and VLDL-C were negatively but non-significantly correlated.

### Discussion

The TAG, TChol and HDL-C levels of Nnewi control participants were significantly decreased compared to the Elele control participants and this may not be unconnected with the type of food being consumed by Elele control participants who consume more natural foods than their counterparts in the urban Nnewi environment. These results were similar to that of Emma-Okon *et al.* and Kasia *et al.* in unexposed participants in Abeokuta, Nigeria [25, 26]. However, although the LDL-C of Elele did not differ significantly from the Nnewi control participants, the numerical value was higher. The high LDL-C level portends a warning signal to the Elele participants who may be more likely exposed to the development of cholesterol-based diseases such as cardiovascular disease and hypertension [27].

The TAG (triglycerides), total cholesterol (TChol), high density lipoproteins cholesterol (HDL-C), low density lipoprotein-cholesterol (LDL-C) and very low density lipoprotein cholesterol (VLDL-C) levels of the factory workers and control participants were estimated in this study. No significant statistical difference was observed between the control TAG and those of the acid battery manufacturing factory. Increased levels of TAG are seen in cases such as obesity, diabetes and in incidence of high intake of fat, sugar or alcohol [28, 29].

In this work, we reported significantly elevated TChol and LDL-C in the lead acid battery factory than in control participants. According to the American Heart Association [30], TChol  $< 200$  mg/dl and TAG  $< 200$  mg/dl; HDL  $> 40$  mg/dl and LDL  $< 130$  mg/dl, are favourable risk factors. In addition, certain lipid ratios like total cholesterol/HDL cholesterol and the LDL cholesterol/HDL cholesterol ratio also correlate with cardiovascular disease. The TChol and LDL-C levels of lead acid battery reported in this work is in line with the result of Sharma *et al.* that suggested that lead exposure increases cholesterol synthesis and transport to peripheral tissues [31]. Cholesterol is one of the most controllable risk factors for heart disease, heart attack and stroke and it causes cardiovascular disease which is a leading cause of disability and premature death [32]. It is one of the most causative agents of death among various populations in the world.

The National Heart, Lung and Blood Institute recommends total cholesterol be less than 200 mg/dL. Good fat naturally cleanses the entire

body and helps get rid of all heavy metals. The results of cholesterol levels observed in this work shows that total cholesterol was within the normal acceptable range (3-6.5mmol/L or 116-252mg/dl) in the factory workers. However, compared with the value obtained in this work in control participants (3.84mmol/L or 149mg/dl), the TChol of acid battery factory workers of 5.17 were elevated and statistically significant. LDL cholesterol is a signal of adverse effect in the health status of factory workers and in Nnewi in particular. High LDL cholesterol is known to dispose individuals to development of CVD because this lipoprotein can cause cholesterol to become deposited in the walls of the arteries [33, 34]. When cholesterol gets deposited in the walls of the arteries, the arteries become stiff and narrow. If this happens in the coronary arteries, they can become blocked, leading to decreased blood flow and a heart attack. Although LDL cholesterol levels of the factory workers were statistically elevated when compared with the control, they were, however, not above the acceptable upper limit of 3.4mmol/L (130mg/dl). In conditions of elevated concentrations of LDL-C particles, cholesterol promotes atheroma plaque deposits in the walls of arteries, a condition known as atherosclerosis, which is a major contributor of the disease.

In contrast, HDL-cholesterol particles have been the only identified mechanism by which cholesterol can be removed from atheroma. The observed normal HDL-cholesterol observed in this study will rather not allow atheroma progression but bring about decrease. It is generally believed that lower total cholesterol levels tend to correlate with lower rate of atherosclerotic development. The association of atherosclerosis with cholesterol has always been specific with cholesterol transport patterns but not on concentration of total cholesterol. This is imperative since particle number and a large percentage of HDL-C particles, growth of atheroma will be low or even not at all for any given cholesterol concentration.

This work also reported the effect of age and LOS on the lipid profiles of the factory workers. Although there were significant correlations between some lipid profiles with some age groups in the factory, none was statistically significant, however, in the lead acid factory; TChol was significantly correlated with LOS indicating that LOS has effect on the concentrations of TChol. This implies that workers in the lead acid battery factory are likely to be exposed to more dangers of cardiovascular disease and other related lipid-based diseases like hypertension and atherosclerosis [35].

## Conclusion

This study have shown significantly reduced TAG and VLDL-C, elevated Tchol and LDL-C in lead acid battery factory workers when compared with control participants. While the HDL-C level of lead acid battery factory workers was elevated compared with control N but significantly reduced compared with control E participants. This study has revealed a possible risk for cardiovascular disease among lead acid battery factory workers in Nnewi, Nigeria and hence calls for urgent attention.

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