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Assessment of blood lead and haemoglobin levels among battery technicians and local government office workers in South-western Nigeria

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Abstract

Introduction: Human exposure to lead has significant public health problems. Occupational exposure of lead has shifted from industrial sources to battery repair activities. Battery technicians are at risk of exposure to lead via inhalation of fumes, oral ingestion and skin absorption.

Objectives: To assess and compare blood lead and haemoglobin levels of battery technicians and local government office workers in South-western Nigeria

Methods: A cross-sectional study with multi-stage sampling was used to compare battery technicians and office workers in Lagos State. A structured interviewer-administered questionnaire was used for data collection while blood samples were collected for lead and haemoglobin measurements. Chi-squared test, Mann-Whitney U test, Fisher's exact test and Student t-test were used to test for significance at $p \leq 0.05$.

Results: A total of 150 battery technicians and 150 office workers participated in the study. The battery technicians were less educated and earned less but had more years of working experience ($p \leq 0.001$) when compared to office workers. The median (range) blood lead value for battery workers was 9.0 (1.0-24.0) µg/dl compared to office workers 0.3 (0.01-3.2) µg/dl, which was statistically significant. The age of office workers was associated with their blood haemoglobin level.

Conclusions & Recommendations: Blood lead level of battery technicians was significantly higher than that of the office workers but their haemoglobin levels were non-significant. A switch to repair of non-lead batteries, changing the work process by enclosing the battery during repairs, more trainings on lead exposure reduction, use of personal protective devices and regular biological monitoring of lead may control elevated lead level among battery technicians.

Keywords: *battery technicians, blood lead levels, haemoglobin levels, office workers*

Introduction

Human exposure to lead is either through occupational or environmental sources. Occupational exposure to lead has shifted from manufacturing industries to battery repair and recycling activities carried out by technicians (1). Battery technicians engage in dismantling and washing lead battery cells in water (2). During this work, they are inadvertently exposed to excess inhalation of lead fumes and oral ingestion and skin absorption of lead particles (3). Lead is a toxic metal with multi-systemic toxic effects at a very low level of exposure affecting hematopoietic and other body systems (3).

Lead exposure is estimated to account for 21.7 million years lost to disability and death (disability-adjusted life years or DALYs) worldwide due to long-term effects on health, including 30% of the global burden of idiopathic intellectual disability, 4.6% of the global burden of cardiovascular disease and 3% of the global burden of chronic kidney diseases (4). Using World Health Organization data on burden of disease, international and national exposure data revealed that lead contributed about 100–900 DALYs per million people, which was classified as moderate public health significance (5).

In the developing countries, evidence showed that unsound lead-acid battery recycling causes severe pollution and serious public health implications in many African cities (6-7). Kenyan government shut down a lead-acid battery recycling facility in Mombasa based on the fact that at least five workers have died from lead poisoning (6-7). Lead exposure is estimated to account for 143,000 deaths per year with the highest burden in developing regions (1, 8) including Nigeria. In Nigeria, artisanal mining of lead-rich gold ores in Zamfara States affected thousands of artisans and community dwellers including more than 2000 children left with permanent disabilities (9-10).

In Nigeria, using the WHO exposure limit for lead exposed workers, a study carried out in Ibadan and Lagos revealed elevated lead levels (2). Lead poses grave problems for battery technicians which affect their health, the health of family members and the society at large. Their exposure to lead could cause sickness absence from work, loss of productivity and earnings and loss due to cost of treatment of these diseases. Within the ambit of literature search, the descriptive studies carried out in Lagos have been largely among automobile mechanics and only a few specifically among battery technicians. Some of these had been carried out many decades ago while others have failed to investigate health problems of lead on these workers. These battery technicians are exposed gradually to lead fumes without having any idea of the toxic effect of materials they handle or inhale (11). They are also ignorant of what measures to take to prevent them. There are no workplace regulations in place for lead exposure in Nigeria (12). This study assessed blood lead and haemoglobin (Hb) levels and associated factors among battery technician work in southern Nigeria.

Methods

This study was carried out in Lagos State, which is one of the smallest states in Nigeria representing about 0.4% of the entire geographical area of the country with a geographical size of 3,577 km^2 (13). Lagos had a population of 9,113,605 people in 2006 (13). According to the United Nations, by the year 2015, based on 6% growth rate, Lagos had become third largest mega-city in the world (13). Lagos is the commercial city of Nigeria where most of the nation's wealth and economic activity are concentrated. The city has one of the largest and most extensive road networks in West Africa. In 2011, about 332,884 newly registered motor vehicles and motorcycles with 781,545 renewed motor vehicles and motorcycles, giving a total of 1,114,429 vehicles were recorded to travel on these roads (14).

A comparative cross-sectional study was employed in two working groups in Lagos State of South-western Nigeria. One group consisted of battery technicians who had registered with the Nigeria Association of

Battery Technicians Lagos State chapter and worked for at least one year. Workers too ill to participate or absent during the period of data collection were excluded from the study. In addition, female workers and engineering department staff of the local government were excluded on account of gender homogeneity and possible exposure to lead, respectively. The other working group included local government office workers with no history of occupational exposure to lead. They were selected from the same area as the battery technicians to nullify any difference in environmental exposure between the two groups. The local government was also chosen for access to sizable number of workers unexposed to lead metal. Only grade level six and below (junior office workers with similar socio-economic status and level of education) workers who had worked for at least a year were eligible to participate in this study.

The sample size was determined using 5% level of significance (α), 80% power, and Z_{α} and Z_{β} as 1.96 and 0.84, respectively. Based on previous studies (2), number of participants in the battery technician group (exposed) was taken as 20; standard deviation (SD) of their mean blood lead level as 14.94 (2); number in the unexposed group as 20; SD of their blood lead level as 10.27 (2); and effect size (the smallest difference between the means that would be clinically meaningful) as 12.5-45.6 µg/dl. This amounted to a minimum of 138 battery technicians and 138 office workers. Multi-stage sampling method was used to select battery technicians (16) while all local government office workers within the selected areas and branches were recruited for the study.

Twenty questionnaires were pretested at another location not selected for the study to determine if the questions are clear and comprehensive enough to address the set objectives and necessary adjustments were made. Questionnaires were subsequently administered to battery technicians and office workers to collect socio-demographic, occupational and lifestyle history. Anthropometric measurements and blood samples were also collected during working hours in designated office or area approved by Local Government authority. Two medical laboratory scientists and four assistants were trained by the investigator to assist with data collection. Each questionnaire was filled within an average period of 20 minutes. The validity of electronic weighing scale and the stadiometer were ascertained by reference weights of known mass before measurement daily. Height and weight were measured using the standard protocol recommended by International Society for the Advancement of Kin anthropometry (ISAK) (17). Body mass index (BMI) was calculated as body weight divided by height squared and expressed as kg/m^2.

Five and two ml of blood was collected from each participant into EDTA bottle for blood lead level and Hb analysis, respectively. All the sample bottles were labelled using codes on the questionnaire for identification to match the participants. Sample bottles for lead analysis were stored in cold boxes with ice packs. The samples were dispatched for analysis at the end of each day. Sharps were discarded in a safety box and glove were discarded into yellow bags then brought back to Lagos University Teaching Hospital, Lagos for proper medical waste management. All the samples collected from both groups were sent to the Department of Chemistry of the University of Lagos laboratory on the same day for analysis by two laboratory scientists. Blood lead was analysed using a graphite-furnace electro-thermal atomic absorption spectrophotometry (PerkinElmer-AAnalyst-200). Care was taken to prevent contamination from the environment of blood specimens during sample preparation and analysis.

Quality control was ensured by randomly selecting four samples which was sent to Graceful Prime Diagnostics Ltd. and results were consistent with that of the University of Lagos chemistry laboratory. Haemoglobin parameters such as Hb level and packed cell volume were carried out in Aids Prevention Initiative of Nigeria (APIN) laboratory in Lagos University Teaching Hospital, Lagos.

Data analysis

Data were analysed using Statistical Package for the Social Sciences (SPSS) version 20. Blood lead and Hb levels were tested for normality using Kolmogorov-Smirnov test. Differences between proportions and means of variables were carried out using Chi-squared test, Mann-Whitney U test or Fisher exact test for significance with 5% level of significance. A regression analysis was also carried out to define the relationship between the variables.

Table 1: Socio-demographic and characteristics of respondents

Variable	Battery technicians (n=150)	Office workers (n=150)	Test statistic	df	p
Age group (years)					
21 - 30	17 (11.3)	10 (6.7)			
31 - 40	47 (31.3)	38 (25.3)			
41 - 50	49 (32.7)	61 (40.7)	χ^2=8.26	4	0.08
51 - 60	20 (13.3)	31 (20.7)			
> 60	17 (11.3)	10 (6.7)			
Mean (SD)	43.85 (11.6)	45.1 (10.3)			
Marital status					
Single	17 (11.3)	24 (16.0)			
Married	126 (84.0)	122 (81.3)	χ^2=5.6	3	0.11*
Divorced	1 (7.0)	3 (2.0)			
Separated	6 (4.0)	1 (0.7)			
Level of education					
No formal education	8 (5.3)	4 (2.7)			
Primary	72 (48.0)	46 (30.7)			
Secondary	63 (42.0)	56 (37.3)	χ^2=21.53	3	**<0.001**
Tertiary	7 (4.7)	44 (29.3)			
Estimated income (Naira)					
< 18,000	54 (36.0)	33 (22.0)			
18,000 - 37,999	57 (38.0)	57 (38.0)			
38,000 - 57,999	32 (21.3)	42 (28.0)	χ^2=12.59	5	**0.02***
58,000 - 77,999	3 (2.0)	12 (8.0)			
78,000 - 97,999	2 (1.3)	4 (2.7)			
≥ 98,000	2 (1.3)	2 (1.3)			
Years of work					
0 - 9	29 (19.3)	53 (35.3)			
10 - 19	49 (32.7)	59 (39.3)	χ^2=18.46	2	**<0.001**
20 and above	72 (48.0)	38 (25.3)			
Median (Range)	18.5 (4.0-50.0)	11.5 (2.0-35.0)	Z=5.27		**<0.001**
Daily work hours					
0 - 8	43 (28.7)	106 (70.7)			
> 8	107 (71.3)	44 (29.3)	χ^2=52.92	1	**<0.001**
Median (Range)	10.0 (0.02-16.0)	8.0 (2.0-24.0)	Z=4.58		**<0.001**
Had training on first aid	52 (34.7)	42 (28.0)	χ^2=1.55	1	0.21

* Fisher exact test; Z=Mann-Whitney U test; $\chi2$=Chi-squared test

Results

A total of 150 battery technicians and 150 local government office workers were interviewed. The age distribution varied with 32.7% of the battery technicians and 40.7% of the office workers being within 41-50 age group. The battery technicians had significantly more years of experience and daily working hours than office workers. They also had more training on first aid but did not show a significant difference (Table 1).

The battery technicians showed a wide blood lead level distribution while the office workers did not. This difference was significant ($p \le 0.001$). Their median (IQR) blood lead value was also extremely high 9.0 (10.3) (µg/dl) compared to 0.3 (0.6) (µg/dl) of the office workers ($p \le 0.001$). In contrast, there was no significant difference in the Hb level of the two groups (Table 2).

Table 2: Blood lead and haemoglobin levels of respondents

Variable	Battery technicians (n=150)	Office workers (n=150)	Test statistics	df	p
Blood lead level (µg/dl)					
0.00 - 4.99	45 (30.0)	150 (100.0)			
5.00 - 9.99	33 (22.0)	0 (0.0)	χ^2=161.54	3	**<0.001**
10.00 - 19.99	56 (37.3)	0 (0.0)			
≥ 20.00	16 (10.7)	0 (0.0)			
Median lead (IQR)	9.0 (10.3)	0.3 (0.6)	Z=-14.8		**<0.001**
Haemoglobin level (mg/dl)					
Severe anaemia (Hb < 8.0)	3 (2.0)	0 (0.0)			
Moderate anaemia (8.0-10.9 Hb)	4 (2.7)	1 (7.0)			
Mild anaemia (11.0-12.9 Hb)	20 (13.3)	24 (16.0)	χ^2=4.64		0.18*
Normal (≥ 13.0 Hb)	123 (82.0)	125 (83.3)			
% Anaemia of public health significance	18.0	16.7			
Median Hb (IQR)	14.35 (2.0)	14.75 (2.1)	Z=-1.01		0.31

* Fisher exact test

A significant association of higher blood lead level (≥5.0 µg/dl) was noted in older battery technicians compared to the young counterparts. There were however no significant associations of higher blood lead level with their marital status, level of education, income, year of work, daily work hours and BMI (Table 3).

With regards to Hb, elderly workers (27.8%) among the battery technicians had a low Hb level compared to the younger workers (18.2%). However, this was not statistically significant ($p=0.5$). In contrast, among the office workers, the middle aged (21.4%) had a significantly low Hb level than young workers (4.9%) ($p=0.04$) (Table 4).

Table 3: Association of blood lead levels (BLL in µg/dl) with socio-demographic/occupational characteristics of battery technicians (N=150)

Variable	BLL <5.0	BLL ≥5.0	χ^2	df	p
Age group (years)					
< 40	15 (27.3)	40 (72.7)			
40 - 59	19 (24.7)	58 (75.3)	9.53	2	**0.009**
≥ 60	11(61.1)	7 (38.9)			
Marital status					
Single	4 (23.5)	13 (76.5)			
Ever married	41 (30.8)	92 (69.2)	0.38	1	0.54
Education					
No formal education	3 (37.5)	5 (62.5)			
At least primary	42 (29.6)	100 (70.4)		1	0.69*
Estimated income (Naira)					
< 18,000	15 (27.8)	39 (72.2)			
18,000 and above	30 (31.2)	66 (68.8)	0.2	1	0.66
Years of work					
0 - 9	6 (20.7)	23 (79.3)			
≥ 10	39 (32.2)	82 (67.8)	1.48	1	0.22
Daily work hours					
0 - 8	13 (30.2)	30 (69.8)			
> 8	32 (29.9)	75 (70.1)	0.02	1	0.97
Body mass index (kg/m^{-2})					
< 25.00	37 (33.3)	74 (66.7)			
25 and above	8 (20.5)	31 (79.5)	2.26	1	0.13

*Fisher exact test

A logistic regression was performed among battery technicians to ascertain the effect of socio-demographic, occupational and lifestyle factors on the likelihood of having elevated blood lead levels (Table 5).

The model explained 55.9% (Nagelkerke R^2) of the variance. The probability of blood lead level decreased with older age while it increased with years of working and level of education.

For office workers, a model explained 23.4% (Nagelkerke R^2) of the variance of Hb levels. The probability of low Hb decreased with age while it increased with BMI. No model was statistically significant when compared to null for lead level amongst office workers (Table 5).

Table 4: Association of haemoglobin (Hb in g/dl) between socio-demographic /occupational characteristics of respondents

Variable	Battery technicians				Office workers			
	Hb <13.0	Hb ≥13.0	χ^2	p	Hb <13.0	Hb ≥13.0	χ^2	p
Age group (years)								
< 40	10 (18.2)	45 (81.8)			2 (4.9)	39 (95.1)		
40 - 59	12 (15.6)	65 (84.4)	1.62	0.52*	21 (21.4)	77 (78.6)	6.25	0.04*
≥ 60	5 (27.8)	13 (72.2)			2 (18.2)	9 (81.8)		
Marital status								
Single	3 (17.6)	14 (82.4)			2 (12.5)	21 (87.5)		
Ever married	24 (18.0)	109 (82.0)		1.00*	22 (17.5)	104 (82.5)		0.77*
Level of education								
No formal	3 (37.5)	5 (62.5)			1 (25.0)	3 (75.0)		
At least primary	24 (16.9)	118 (63.1)		0.14	24 (16.4)	122 (83.6)		0.52*
Estimated income								
< 18,000	12 (22.2)	42 (77.8)			6 (20.7)	23 (79.1)		
18,000 and above	15 (15.6)	81 (84.4)	1.02	0.31	19 (15.70	102 (84.5)		0.58*
Years of work								
0 - 9	6 (20.7)	23 (79.3)			8 (15.1)	45 (84.9)		
≥ 10	21 (17.4)	100 (82.6)	0.18	0.68	17 (17.5)	80 (82.5)	0.15	0.7
Daily work hours								
0 - 8	7 (16.3)	36 (83.7)			17 (16.0)	89 (84.0)		
> 8	20 (18.7)	87 (81.3)	0.12	0.73	8 (18.2)	36 (81.8)	0.1	0.75
Body mass index (kg/m^{-2})								
< 25	24 (21.6)	87 (78.4)			18 (19.6)	74 (80.4)	1.44	0.23
25 and above	3 (7.7)	36 (92.3)	3.79	0.05	7 (12.1)	51 (87.9)		

*Fisher exact test

Discussion

The median (range) blood lead level among battery workers compared to office workers was statistically significant. Majority of battery technicians had blood lead levels greater than 5 µg/dl. The study conducted among lead workers and unexposed group in Jimma, Ethiopia, reported doubled the above-mentioned values for blood lead levels for exposed workers (11). This may be due to their working in an enclosed settings (garage); hence, the lead concentration in such places is higher than what is exposed to at road side, as observed in the study on automobile technicians in Lagos State (18).

High mean blood lead values as high as 112.5 (SD=14.24) and 93.85 (SD=16.70) µg/dl respectively had been reported among battery technicians in Lagos and Ibadan cities of Nigeria years back (2). In 2010, another study carried out among lead workers at Ile-Ife, Nigeria reported extremely lower mean blood lead level of 6.81 (SD=2.61) µg/dl (19). This was attributed to the fact that Nigeria, alongside other countries of Sub-Saharan Africa, achieved a complete phase-out of leaded gasoline around 2005 with the help of United Environmental Protection Agency (19, 20). Airborne lead has been reported to be the major source of human exposure to lead in developing countries, of which

90% is from leaded gasoline (21). The remaining 10% accounts for occupational exposure and other environmental sources in addition to gasoline. The NHANES (National Health and Nutrition Examination Survey), USA revealed that a 50% drop in the use of leaded petrol had resulted in a 30% drop in mean blood lead levels among people between 1976 and 1980 (22). This further supports the substantial reduction of high blood lead levels of both groups in the study compared to blood lead levels reported in earlier decades. Moreover, Ethiopia, alongside other Sub-Saharan African countries attained total freedom from lead petrol in 2005 (20).

Table 5: Factors associated with blood lead level amongst battery technicians and haemoglobin level amongst office workers

Factors	β	SE	Significance	Odds ratio	95% CI for Exp (β)	
					Lower	Upper
Blood lead level among battery technicians						
Age (years)	-0.256	0.099	**0.01**	0.77	0.64	0.94
Body mass index (kg/m^{-2})	0.295	0.151	0.05	1.34	1.0	1.81
Years of working	0.277	0.100	**0.005**	1.32	1.09	1.6
Working hours	-0.508	0.264	0.06	0.6	0.36	1.01
Had training	0.313	1.001	0.76	1.37	0.19	9.72
Cigarette smoking (years)	-0.033	0.042	0.43	0.97	0.89	1.05
Education group	2.306	1.086	**0.03**	10.03	1.19	84.37
Cigarette smoking (stick)	0.004	0.022	0.84	1.0	0.96	1.05
Haemoglobin among office workers						
Age (years)	-0.086	0.027	**0.001**	0.92	0.87	0.97
Body mass index (kg/m^{-2})	0.135	0.068	0.05	1.15	1.0	1.31
Smoking status						
Ex-smoker	0.592	0.654	0.37	1.81	0.5	6.52
Current smoker	2.854	1.535	0.06	17.36	0.86	351.96
Alcohol consumption habit						
Former drinker	-0.87	0.529	0.1	0.42	0.15	1.18
Current drinker	0.196	1.168	0.87	1.22	0.12	11.99

A significantly higher blood lead level was also reported from Manila, Philippine amongst lead exposed workers compared to unexposed workers (23). The comparison was between battery workers and radiator workers. The blood lead level of battery workers was almost twice of that in radiator workers. This significance was corroborated by other studies from Jordan (24), Iran (25, 26) Karachi, Pakistan (3) and Kurnool, India (27). It can be alluded that battery technicians that repair and recharges are more at risk of elevated blood lead compared to those that only charges battery. The study on correlation between iron deficiency and lead intoxication among battery workers revealed a significant association (28).

The prevalence of anaemia among both battery technicians and office workers was of moderate type. There was no statistically significant difference between their median Hb values. Similar results were reported from Macedonia (29) and from Bangladesh demonstrating a level of 11.4 (SD=0.75) µg/dl (30). This could be due to proportionately high blood lead level among these workers. In contrast, the study conducted among battery technicians in Manila, Philippine revealed a blood lead value >40 µg/dl and (Hb <13 g/dl for males) (23). This high percentage maybe due to elevated blood lead level compared to reference study which recorded 24.00 µg/dl as the highest blood lead level. The study carried out in Iran showed mean Hb value within normal range (25), which might be due to relatively young study population with few working years of working and few years of exposure to battery lead. Similar results which were significant emanated from another study (26). However, the mean lead level from a study on correlation between iron deficiency and lead intoxication reported a non-significant difference (28).

This present study noted a significant association between age of the battery technicians and their blood lead level. The study done at Karachi, Pakistan reported similar results (3). Macedonian study also found age of lead workers to be directly associated with their blood lead level (29). It implied that long duration of exposure could be a significant factor in the elevation of blood lead level. This finding may inform the battery technicians to adopting preventive and control measures such as taking break from work and use of protective devices. Elevated blood level was also found to be associated with higher level of education and BMI. Higher level of education may translate to higher standard of living, which could lead to additional exposure to environmental/other occupational lead.

Among office workers, low Hb level decreases with decreasing age while high Hb level increases with their BMI. Higher BMI may be a result of dietary, stress and living standards among other factors and 90% (severe public health significance) were anaemic expectedly increases haemoglobin level.

A potential bias in this study was recall and instrument bias. The recall on occupational history and lifestyle risk factors was self-reported; this was prevented by asking less ambiguous questions. Another limitation was instrument bias from blood sampling and anthropometric measurements. Blood samples were taken during the same period of the day (12–4 pm) to avoid subject variation. To avoid measurement bias, same research assistants were trained in questionnaire administering and blood sampling. Overall, these biases may not have affected study results significantly.

Conclusions & Recommendations

Blood lead levels of battery technicians was significantly higher than that of the office workers but their Hb level was not. The level correlated significantly with their working hours. The likelihood of low blood lead level decreases with decreasing age of battery technicians and increases with their BMI, years of working and level of education. As for Hb, the probability of low-level decreases with age of office worker and increases with their BMI. A switch to repair of non-lead batteries, changing the work process by enclosing the battery during repairs, more trainings on lead exposure reduction, use of personal protective devices and regular biological monitoring of lead may control elevated lead level amongst battery technicians.

Public Health Implications

- The study demonstrated that battery technician job is associated with chemical hazard such as lead.
- Duration of exposure was an established determinant of elevated blood lead level among these workers.
- Emphasis on preventive programs according to hierarchy of control of hazards is needed to address this hazard amongst these group of workers.

Author Declarations

Competing interests: The authors declare that they have no competing interests.

Ethics approval and consent to participate: Ethical clearance was granted by the Ethics Review Committee of the Lagos University Teaching Hospital (ADM/DST/HREC/APP/759). Informed written consent was obtained from each participant prior to data collection.

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References

1. World Health Organization. *Lead Poisoning and Health Fact Sheet.* Geneva: World Health Organization, 2015. Available from: http://www.whoint/mediacentre/factsheets/.../e.
2. Peter AO. Total blood and urinary lead levels in battery charging artisans in two metropolitan cities of South West Nigeria. *J Appl Biosci* 2009; 14: 796-799. Available from: https://www.m.elewa.org/JABS/2009/14/7BLOCKED.pdf.
3. Haider MJ, Qureshi N. Studies on battery repair and recycling workers occupationally exposed to lead in Karachi. *Rocz Panstw Zakl Hig* 2013; 64(1): 37-42. https://www.m.elewa.org/JABS/2009/14/7BLOCKED.pdf.
4. World Health Organization. *International Lead Poisoning Prevention Week of Action*. Geneva: WHO 2022. Available from: http://www. https://www.who.int/news/item/23-10-2022-almost-1-million-people-die-every-year-due-to-lead-poisoning--with-more-children-suffering-long-term-health-effects.
5. Hänninen O, Knol AB, Jantunen M, Lim TA, Conrad A, Rappolder M, et al. Environmental burden of disease in Europe: assessing nine risk factors in six countries. *Environ Health Perspect* 2014; 122(5): 439-446. http://www.ncbi.nlm.nih.gov/pubmed/24584099
6. Ericson B, Otieno VO, Nganga C, St. Fort J, Taylor MP. Assessment of the presence of soil lead contamination near a former lead smelter in Mombasa, Kenya. *J Health Pollut* 2019; 9(21): 190307. https://doi.org/10.5696/2156-9614-9.21.190307.
7. Manhart A, Amera T, Kuepouo G, Mathai D, Mng'anya S, Schleicher T. *The deadly business-findings from the Lead Recycling Africa Project*. Öko-InstituteV, 2016. Available from: https://www.oeko.de/oekodoc/2549/2016-076-de.pdf.
8. Prüss-Ustün A, Vickers C, Haefliger P, Bertollini R. Knowns and unknowns on burden of disease due to chemicals: a systematic review. *Environ Health* 2011; 10(1): 1. https://ehjournal.biomedcentral.com/counter/pdf/10.1186/1476-069X-10-9.pdf.
9. Abdulkareem JH, Abdulkadir A, Abdu N. Vertical distribution of lead (Pb) in farmlands around contaminated goldmine in Zamfara state, Northern Nigeria. *African J Agric Res* 2015; 10(53): 4975-4989. http://academicjournals.org/journal/AJAR/article-abstract/46C72C456584.
10. Medecins Sans Frontieres. *Lead poisoning crisis in Zamfara State Northern Nigeria.* Medecins Sans Frontieres, June 2012. Available from: https://www.msf.org/sites/default/files/2018-06/MSF-Nigeria-Lead.pdf.
11. Adela Y, Ambelu A, Tessema DA. Occupational lead exposure among automotive garage workers – a case study for Jimma Town, Ethiopia. *J Occup Med Toxicol* 2012; 7: 15. https://occup-med.biomedcentral.com/articles/10.1186/1745-6673-7-15.
12. Rasheed TO. Safety practices on lead poisoning among battery technicians in Lagos, Nigeria. *Cent African J Public Heal* 2018; 4(1): 27-33.

https://doi.org/10.11648/j.cajph.20180401.15.

13. Nwambuonwo OJ, Mughele ES. Using Geographic information system to select suitable landfill sites for megacities (case study of Lagos, Nigeria). *Comput Inf Syst Dev Informatics* 2012; 3(4): 48-57. https://core.ac.uk/download/pdf/234697228.pdf.

14. Lagos Bureau of Statistics Ministry of Economic Planning And Budget Secretariat, Alausa, Ikeja L. *Motor Vehicles Statistics, 2012.* Available from: https://nairametrics.com/wp-content/uploads/2013/03/Lagos-State-LGA-Statistics-2012.pdf.

15. Sharma S, Mudgal S, Thakur K, Gaur R. How to calculate sample size for observational and experiential nursing research studies? *Natl J Physiol Pharm Pharmacol* 2019; 10(0): 1. file:///C:/Users/PC/Downloads/SampleSizePaper%20(1).pdf.

16. Elder S. *School to Work Transition Survey: a Methodological Guide.* Geneva: International Labour Office, 2009. Available from: http://www.ilo.org/employment/Areasofwork/lang--en/facet--LOC.EMP-_-EMP.YOU-_-TYP-_-InstructionalMaterial-2772/WCMS_DOC_EMP_ARE_YOU_EN/index.htm%5Cnpapers2://publication/uuid/C7DF1095-31ED-48BB-A640-613888FE0E82.

17. Marfell-Jones M, Olds T, Stewart A, Carter L. *International Standards For Anthropometric Assessment.* Brussel, 2006.

18. Saliu A, Adebayo O, Kofoworola O. Comparative assessment of blood lead levels of automobile technicians in organised and roadside garages in Lagos, Nigeria. *J Environ Public Health* 2015; 2: 1-9. https://doi.org/10.1155/2015/976563.

19. Ojo JO, Oketayo OO, Horvat M. Marked lowering in pb blood levels follows lead phase-out from gasoline in Nigeria. *Eff Hum Heal* 2010; 904-947. https://inis.iaea.org/collection/NCLCollectionStore/_Public/41/131/41131315.pdf.

20. United Nations Environment Programme (UNEP). *Outcome and influence evaluation of the UNEP partnership for clean fuels and vehicles (PCFV).* UNEP, October 2010. Available from: http:/www.unep.org/transpor/pcfv/PDF/leadphaseoutreport.pdf.

21. Jalal A. *National Conference on the Phase-out of Leaded Gasoline in Nigeria Working Paper 6.* The World Bank Clean Air Initiative in Sub-Saharan African Cities, November15-16, 2001.

22. Thomas M. The elimination of lead in gasoline. *Annu Rev Energy Env* 1995; 20(1): 301-324. https://doi.org/10.1146/annurev.eg.20.110195.001505.

23. Suplido ML, Ong CN. Lead exposure among small-scale battery recyclers, automobile radiator mechanics, and their children in Manila, Philippines. *Environ Res* 2000; 82(3): 231-238. https://doi.org/10.1006/enrs.1999.4024.

24. Nusier MK, El-Akawi ZJ, Bani-Hani I. Blood lead levels and gamma-glutamyl transferase activity in battery factory workers in Jordan. *Saudi Med. J.* 2003; 24(9): 941-944. https://www.researchgate.net/profile/Mohamad-Nusier/publication/297325762_Blood_lead_levels_and_gamma-glutamyl_transferase_activity_in_battery_factory_workers_in_Jordan/links/5ddeb64792851c83644e2b4e/Blood-lead-levels-and-gamma-glutamyl-transferase-activity-in-battery-factory-workers-in-Jordan.pdf.

25. Kianoush S, Balali-Mood M, Mousavi SR, Shakeri MT, Dadpour B, Moradi V, et al. Clinical, toxicological, biochemical, and hematologic parameters in lead exposed workers of a car battery industry. *Iran J Med Sci* 2013; 38(1): 30-37. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3642942&tool=pmcentrez&rendertype=abstract.

26. Malekirad AA, Kalantari-Dehaghi R, Abdollahi M. Clinical, haematological, and neurocognitive findings in lead-exposed workers of a battery plant in Iran. *Arh Hig Rada Toksikol* 2013; 64(4): 497-503. http://www.ncbi.nlm.nih.gov/pubmed/24384755

27. Naidana PS, Chakravarthi Burra K, Peesapati S. A study on lead toxicity among the workers in an unorganized sector of lead-acid battery industry. *Al Ameen J Med Sci* 2013; 6(4):350-355. http://ajms.alameenmedical.org/ArticlePDFs/AJMS%20V6.N4.2013%20p%20350-354.pdf.

28. Keramati MR, Sadeghian MH, Mood M. Correlation between iron deficiency and lead intoxication in the workers of a car battery plant. *Int J Hematol Oncol* 2010; 20(3): 169-175.

29. Stoleski S, Karadžinska-Bislimovska J, Stikova E, Risteska-Kuc S, Mijakoski D MJ. Adverse effects in workers exposed to inorganic lead. *Arch Ind Hyg Toxicol* 2008;(4): 19-29. https://doi.org/10.2478/10004-1254-59-2008-1866.

30. Ahmad SA, Khan MH, Khandker S, Sarwar a FM, Yasmin N, Faruquee MH, et al. Blood lead levels and health problems of lead acid battery workers in Bangladesh. *Sci W J* 2014: 1-5. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3953567&tool=pmcentrez&rendertype=abstract.