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Assessment of Lead in Urine Samples Among Undergraduate University Students

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Abstract

Lead (Pb) is a widespread environmental pollutant with serious health consequences, especially in developing countries. To assess potential exposure concerns, this study measured lead levels in urine samples collected from undergraduate students at the University of Abuja, Nigeria. A cross-sectional study was conducted among 138 consenting undergraduates drawn from five faculties using simple random sampling. Spot urine samples were obtained and analysed using Atomic Absorption Spectrophotometry, while a structured questionnaire was used to collect socio-demographic and environmental exposure information. Results indicated that 5.8% of respondents had high urinary Pb levels (≥10 µg/dL), 49.3% had detectable levels below this threshold, and 44.9% had no detectable Pb. A significant relationship was found between place of residence and urine lead concentration. Students residing near high-traffic and industrial areas had higher Pb levels. The findings highlight the importance of continual environmental monitoring, health education, and public health interventions to reduce heavy metal exposure among university students.

Introduction

Lead is naturally occurring and is found throughout the Earth’s crust [1]. They are also released into the environment through human activities. Their widespread use has resulted in extensive environmental contamination, harmful human exposure, and significant public health problems in many parts of the world [2]. Anthropogenic activities such as mining and smelting operations, industrial production and use of industrial products, as well as domestic and agricultural use of metals and other metal-containing compounds, are common sources of human exposure to lead and other heavy metals [3]. Environmental contamination can also occur through weathering of the Earth’s crust, soil erosion, urban runoff, sewage discharge, batteries, ceramic glazes, jewellery, toys, cosmetics, traditional medicines, and many other sources. Industrial sources include metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations, high-tension lines, plastics, textiles, microelectronics, wood preservation, and paper processing plants [4]. Inhalation of airborne dust or particles generated by burning materials containing Pb, and ingestion of Pb-contaminated water, food, soil, etc., are common routes of exposure in humans [2]. Lead, in general, is not biodegradable; it has long half-lives and has the potential to accumulate in various body organs, leading to undesirable side effects [5].

The determination of lead in urine has been the subject of continuous interest in the biomedical and environmental sciences. Urine is a key matrix for lead analysis due to its simple collection, storage, and sample preparation; hence, it is widely used to estimate exposure. Analysis of urine samples better reflects the total body intake of certain elements than analysis of other biological fluids [6]. Once Pb enters the body, they are distributed to organs such as the brain, kidneys, liver, and bones. The body stores lead in the teeth, bones, and other tissues, where it accumulates over time, while some of it is removed from the body through the excretory system. [2]. The excessive amounts of these metals, especially lead, in food are associated with the etiology of a number of diseases, particularly cardiovascular, kidney, nervous, and bone diseases. Lead is well known for its toxicity and adverse effects on human health. Absorption of ingested lead may constitute a serious risk to public health. Some chronic effects of Pb poisoning are colic, constipation, and anemia [7]. Heavy metals like Pb have become widely used in virtually every aspect of society. The estimated global burden of disease attributable to Pb exposure is 0.6% [8]. Every year, new incidences of work-related diseases secondary to exposure to heavy metals like Pb are a major potential public health problem throughout the world, particularly in developing countries like Nigeria [9]. Most of our knowledge of the toxic effects of lead on health comes largely from studies conducted in populations with relatively high Pb exposure, such as workers in industry or in heavily polluted environments. Only in the last few years have studies concerning human exposure to lead, particularly in developing countries like Nigeria, been undertaken [9]. Consequently, it has been argued that adolescents and youth may be more susceptible to toxic exposure than other population groups because they have proportionally greater intake of food contaminants, active developmental processes, multiple exposure pathways, and more susceptible socio-behavioural activities [10, 11].

The University of Abuja is undergoing a phase of rapid development in its infrastructure, with the introduction of new courses and an increasing student enrolment rate, clear indicators of this. However, as the number of students increases and the need for the steady relocation of staff and students from the Gwagwalada mini campus to the Main Campus grows, so too do other public health issues and the risk of students' exposure to environmental toxicants. Newer structures are being erected with state-of-the-art appliances coated with heavy metals, which are increasingly used in modern architecture. Thus, this study aims to determine the level of lead in urine samples from undergraduate students at the University of Abuja.

Material and Methods

Study area

The University of Abuja is the only government-owned tertiary institution in the Nigerian capital, Abuja. The latitude of Gwagwalada, Nigeria, is 8.950833, and the longitude is 7.076737. Gwagwalada, Nigeria, is located in Nigeria in the Towns category with GPS coordinates 8° 57^{l} 2.9988” N and 7°4^{l} 36.2532” E (latlong.net). Gwagwalada is an area council in the Federal Capital Territory in Nigeria. It is selected because it is characterized by different industrial, commercial, and heavy traffic around and within the city. At the same time, because of the large scale of movement carried out in this area. Gwagwalada is also the name of the main city in the

Local Government Area, which has an area of 1,043 km and a population of 157,770 at the 2006 census [12].

Study population and inclusion criteria

The study population comprises all undergraduate students of the University of Abuja. The study included all regular undergraduates at the University of Abuja at the time of the study who gave consent to participate. The exclusion criteria include postgraduate students and all students in diploma or remedial studies.

Study design

The study design involves collecting urine samples from consenting participants and using a questionnaire to assess students' demographics.

Sample size determination

Sample size was determined using the Leslie–Kish formula as described by [13]:

$n = (Z^2 \times p \times q) / d^2$

where n represents the minimum sample size, Z is the standard normal deviation corresponding to a 95% confidence level (1.96), p is the estimated proportion of Nigerians in urban areas with blood lead levels above the action level of 10 µg/dL (0.10), $q = 1 - p$ (0.90), and d is the desired precision (0.05). Substituting these values gave a minimum sample size of 138. To account for a 10% non-response rate, the final sample size was increased to 152 participants.

Sampling technique

A simple random sampling technique was used to select five faculties from the total of eleven faculties at the University of Abuja. Questionnaires were administered to all consenting students in these faculties until all consenting students had been studied and the sample size was complete.

Data collection

The data was collected using a questionnaire survey. This was formulated using a tool designed to capture global standards for quality health care services. These instruments were self-administered and were pre-tested with a selected number of students who

Table 1 Socio-demographic findings of respondents.

Variable		Male (n=72)	Female (n=66)
Age grouping (years)	16-20	14 (10.14)	26 (18.84)
	21-25	50 (36.23)	35 (25.36)
	26-30	7 (5.07)	5 (3.62)
	31-35	1 (0.72)	0 (0)
Religion	Islam	16 (11.59)	13 (9.42)
	Christianity	56 (40.58)	53 (39.86)
Marital status	Single	71 (51.4)	65 (47.1)
	Married	1 (0.72)	1 (0.72)
Faculty	College of Health Sciences	32 (23.19)	17 (12.32)
	Veterinary medicine	21 (15.22)	19 (13.77)
	Science	16 (11.59)	14 (10.14)
	Art	1 (0.72)	3 (2.17)
	Social science	2 (1.45)	13 (9.42)
Tribe	Gwari/ Gbagyi	1 (0.72)	1 (0.72)
	Hausa	0 (0.0)	8 (8.80)
	Yoruba	33 (23.91)	25 (18.11)
	Igbo	17 (12.32)	12 (8.70)
	Others	21 (15.22)	20 (14.49)
Place of residence	Main campus	53 (38.40)	59 (42.75)
	Mini campus	0 (0.0)	1 (0.72)
	Around the main campus	5 (3.62)	3 (2.17)
	Around the mini campus	4 (2.90)	0 (0.0)
	Other	10 (7.2)	3 (2.17)

were not part of the selected faculties before the commencement of the study. The questionnaire survey sought to obtain the socio-demographic details of the participants while keeping the confidentiality of the information collected through anonymizing the data.

Sample collection and analysis

Spot urine samples of the participants were collected directly into 20 ml disposable bottles. The samples were diluted with 10 mL of 1% nitric acid and sent for further analysis using an atomic absorption spectrophotometer, as described in [6, 7]. Briefly, a blank reagent was prepared with 2 ml of distilled water, and a calibration curve was constructed using standard solutions at 10 and 5 ppm (µg/100 ml). The absorbance of the working standard corrected for the blank reagent was plotted. The most sensitive absorption line was listed first, followed by measurement of the less sensitive line. For the measurements, two determinations were to be made from each sample, and the mean Pb rate was to be obtained.

Data analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 21. The result was presented in frequency tables and charts. A confidence interval of 95% was used, and a P-value of ≤ 0.05 was considered statistically significant.

Ethical consideration

Ethical clearance was sought and obtained from the University of Abuja. The purpose of the study was explained to the participants, and written consent was sought and obtained, with the confidentiality and anonymity of the information they provided assured. Using anonymous questions and conducting interviews privately ensured respondents' confidentiality.

Results and Discussion

Socio-demographic characteristics of respondents

The socio-demographic characteristics of the respondents are presented in Table 1. A total of 138 respondents participated in the study, comprising 72 males and 66 females. The majority of respondents were aged 21–25 years, accounting for 36.23% of males and 25.36% of females. This finding suggests that most participants were young adults, which is expected in a university environment. Similar demographic distributions among university students have been reported by [14]. In South Africa, young adults constituted the dominant study population in lead exposure assessments. Christianity was the predominant religion among participants, while most respondents were single. In terms of faculty distribution, respondents from the College of Health Sciences and Veterinary Medicine formed the majority of participants. The Yoruba ethnicity was the largest tribal group among respondents, followed by the Igbo and other ethnic groups. Most respondents resided on the main campus, which may influence exposure patterns due to shared environmental conditions. The predominance of students residing on campus may expose them to common environmental pollutants, including vehicular emissions, waste disposal activities, and urban dust. According to Nriagu et al. [16], environmental lead contamination in African urban settings is strongly associated with residential and infrastructural characteristics.

Urinary lead levels among respondents

Table 2 shows the urinary lead concentrations among respondents. The results revealed that 5.8% of respondents had high urinary lead levels (≥10 µg/dL), while 49.3% had detectable but mild levels below the reference range. Additionally, 44.9% showed no detectable lead levels. The presence of detectable lead levels in more than half of the respondents indicates ongoing environmental lead exposure in the study area. Although only a small proportion exhibited high concentrations, the detection of low-level exposure remains a public health concern because chronic exposure to even minimal lead concentrations may produce adverse health effects over time. This observation aligns with another finding [7], which reported that no level of lead exposure can be considered completely safe due to its cumulative toxic effects. Similarly, long-term low-dose lead exposure contributes significantly to the global burden of disease, particularly affecting the neurological, renal, and cardiovascular systems [8]. However, the relatively low prevalence of high lead

Table 2 Lead levels obtained from the urine samples of the respondents.

Lead level	Concentration	N (%)
High	≥10µg/dL	8 (5.8)
Mild (>reference range)	>0 but <10µg/dL	68 (49.3)
Absent	≤ 0	62 (44.9)

Table 3 Association between demographic characteristics of respondents and urine lead levels.

Variables	Urine concentration of lead						
	Responses	**High**	**Low**	**Absent**	χ^2	**df**	**P-value**
Sex	Male	4	37	31	0.269	2	0.874
	Female	4	31	31			
Level of study	100 level	0	1	4	5.604	10	0.847
	200 level	1	20	18			
	300 level	2	11	12			
	400 level	3	21	13			
	500 level	1	9	10			
	600 level	1	6	5			
Faculty	College of Health Science	1	27	21	12.63	8	0.125
	Veterinary Medicine	2	16	22			
	Social science	0	7	8			
	Science	4	15	11			
	Art	1	3	0			
Age distribution	16-20	1	19	20	4.41	6	0.621
	21-25	6	41	38			
	26-30	1	8	3			
	31-35	0	0	1			

Table 4 Association between household variables and urine lead levels.

Variables	Urine concentration of lead						
	Responses	**High**	**Low**	**Absent**	χ^2	**df**	**P-value**
Place of residence	Main campus	6	48	58	17.35	8	0.007*
	Mini campus	0	1	0			
	Around the main campus	0	8	0			
	Around the Mini campus	1	3	0			
	Others	1	8	4			
Proximity to the main road	Right next to it	1	2	3	3.49		0.747
	5m away	1	19	23			
	5-10m away	2	23	23			
	>10m away	4	24	23			
Level of traffic activity from the place of residence	Less busy	0	6	6	5.31	4	0.257
	Average	4	22	12			
	Very busy	4	40	44			
Chronic use of a drug/medication	Yes	0	3	5	1.32	2	0.518
	No	8	65	57			
Material floor is made from	Cement	1	10	5	1.96	4	0.208
	Tiles	7	56	54			
	Others	0	2	3			
Material roof is made from	Roofing tiles	1	13	7	2.60	6	0.857
	POP	4	32	29			
	Iron sheets	2	11	15			
	Others	1	12	11			
Smoke cigarette	Yes	0	6	6	0.758	2	0.685
	No	8	67	62			
Passive Smoker	Yes	2	19	8	4.50	2	0.105
	No	6	49	54			

* (Statistically significant)

concentration observed in this study contradicts the report of Nriagu et al. [16], who documented substantially higher levels of lead poisoning among African populations exposed to industrial pollution. The disparity may be attributed to improved environmental regulations, the phase-out of leaded gasoline, differences in industrialization levels, and variations in exposure sources between study locations.

Association between demographic characteristics and urinary lead levels

There was no statistically significant association between urinary lead levels and demographic variables, including sex ($p = 0.874$), level of study ($p = 0.847$), faculty ($p = 0.125$), and age distribution ($p = 0.621$; Table 3). Although males showed slightly higher frequencies of elevated lead levels compared to females, the difference was not statistically significant. This suggests that both sexes may experience similar environmental exposure patterns within the study environment. Comparable findings were reported by [15], who found no significant gender variation in childhood lead exposure following the phase-out of leaded gasoline in Uganda. The lack of association between age and lead levels may be explained by the participants' narrow age range, as most respondents were young adults living under similar environmental and socioeconomic conditions. This finding agrees with the report by [14], who observed that environmental exposure factors, rather than demographic characteristics, were stronger predictors of lead burden. Conversely, some studies have reported significant associations between demographic variables and lead exposure. For example, Orisakwe et al. [9] reported that socioeconomic status, occupation, and educational background may influence exposure patterns due to differences in environmental conditions and lifestyle practices. The contradiction may result from differences in study populations, sample size, environmental settings, and exposure sources.

Association between household variables and urinary lead levels

As shown in Table 4, place of residence was statistically significantly associated with urinary lead levels ($p = 0.007$). Respondents residing on the main campus recorded higher rates of detectable lead concentrations than those at other residential locations. This finding suggests that environmental conditions around the main campus may contribute to lead exposure. Potential sources include increased vehicular activity, poor waste disposal systems, contaminated dust particles, and nearby anthropogenic activities. Similar observations were reported by [16], who identified urban residential environments as major contributors to lead exposure in African communities. Likewise, [15] found that residential proximity to polluted environments increased the risk of lead exposure among school-aged children. No statistically significant associations were observed between urinary lead levels and proximity to major roads, traffic density, cigarette smoking, passive smoking, roofing materials, flooring materials, or chronic medication use. Although vehicular emissions have historically contributed to environmental lead contamination, the absence of significance in this study may reflect reduced lead content in modern fuels following regulatory interventions. This observation contradicts earlier reports by [7], who emphasized traffic emissions and tobacco smoke as important contributors to environmental lead exposure. The inconsistency may be due to differences in environmental policies, urbanization patterns, and reduced environmental lead levels in recent years.

Association between environmental exposure variables and urinary lead levels

A statistically significant association was found between proximity to factories and urinary lead levels ($p = 0.023$; Table 5). Respondents residing close to factories exhibited higher urinary lead concentrations compared to those living farther away. Industrial activities are recognized as major sources of environmental lead contamination through emissions, improper waste disposal, and contamination of air, soil, and water. This finding supports the report by [2], which identified industrialization as a primary contributor to heavy metal pollution and human exposure. Similarly, Mishra and De [3] reported that industrial activities significantly increase environmental heavy metal accumulation, thereby increasing human exposure risks. There was no significant association between urinary lead levels and domestic water source, cooking ventilation, cooking fuel, nearby landfill sites, quarry activities, or printing businesses. This suggests that these variables may not represent major exposure pathways within the study area. However, other studies have reported contrasting findings [5] that environmental contaminants may persist in domestic environments through water systems, waste accumulation, and household activities, contributing indirectly to toxic metal exposure. Similarly, Zhou et al. [11]

Table 5 Association between environmental exposure variables and urine lead levels.

Variables	Urine concentration of lead						
	Responses	**High**	**Low**	**Absent**	χ^2	**df**	**P-value**
Domestic Water Usage	Tap	6	40	37	1.931	6	0.748
	Borehole	2	22	22			
	Other	0	6	3			
Vent in the cooking area	Yes	8	59	56	1.459	2	0.482
	No	0	9	6			
Fuel used in cooking	Charcoal	0	3	1	13.67	8	0.091
	Fire wood	0	2	0			
	Kerosene	4	28	39			
	Electricity	1	18	17			
	Other	3	17	5			
Printing business (close to place of residence)	Yes	5	25	29	2.89	4	0.577
	No	3	39	30			
	don't know	0	4	3			
Garbage landfill (close to place of residence)	Yes	1	18	19	1.974	4	0.741
	No	6	41	38			
	don't know	1	9	5			
Quarry (close to place of residence)	Yes	1	0	1	7.803	4	0.099
	No	6	58	51			
	don't know	1	10	9			
Factory (close to place of residence)	Yes	2	7	0	11.34	4	0.023
	No	6	54	57			
	don't know	0	7	5			

emphasized that environmental exposure pathways vary considerably across regions depending on industrial development, waste management practices, and urbanization levels. Overall, the findings of this study indicate that residential location and industrial proximity are important determinants of urinary lead exposure among respondents. The detection of lead in a substantial proportion of participants highlights the need for continuous environmental monitoring, public health awareness, and implementation of pollution control measures to reduce long-term health risks associated with lead exposure.

Conclusion

This study revealed measurable urinary lead levels among undergraduate students at the University of Abuja, confirming environmental lead exposure in this population. While most detected levels were low, the widespread occurrence of lead in urine highlights the need for continued surveillance. Place of residence was significantly associated with urinary lead concentration, emphasizing the importance of environmental conditions in lead exposure. Routine biomonitoring, environmental regulation, and public health education are recommended to minimize exposure and protect student health.

Data availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

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