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Blood Lead Levels in Children Aged 6–59 Months Attending the Children’s Outpatient Clinic at the Federal Teaching Hospital, Ido-Ekiti, Nigeria

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Abstract

Background: Lead, a metal widely used across many industries, including construction, electricity, and fashion, is a heavy metal of public health significance. Exposure to lead can affect normal growth and development in children.

Methods: This cross-sectional study determined blood lead levels of 363 children aged 6- 59 months seen at the Children Outpatients Clinic of the Federal Teaching Hospital, Ido-Ekiti. Children with chronic illness and severe acute malnutrition were excluded. Venous blood was analysed using an atomic absorption spectrophotometer.

Results: BLL ranged between 0.1 µg/dl and 22.8 µg/dl. The median (IQR) BLL was 5.10 (1.80-8.63) µg/dl. Blood lead levels were higher among males than among females ($p = 0.82$). Overall, 48.3% had blood lead levels below 5 µg/dl, and 183 (51.7%) had levels above 5 µg/dl. One subject (0.3%) had a value above 20 µg/dl. Age, gender, and socioeconomic class did not significantly affect BLL ($p = 0.94$, 0.82, and 0.63, respectively). Use of toys with peeled paint, residence close to the highway and storage of water in plastic containers were associated with elevated lead levels.

Conclusion: The majority (51.8%) of children in the locality of study have elevated BLL. There is a need to increase awareness of environmental lead contamination and the dangers of lead exposure. Health promotion should also focus on measures to reduce lead exposure.

Keywords: *Environmental contamination, Heavy metals, Lead toxicity, Paint, Plastic toys, Under-five children.*

Introduction

Lead is a heavy metal of public health importance. Its widespread use in many spheres of human endeavour, including the paint, building, and fashion industries, has increased its levels in soil, water, and air.¹⁻⁴ Contamination of surfaces, the air and food materials increases human exposure to lead and poses a health hazard to the human population. In the human body, lead

has no biological importance and only produces toxic effects. At high levels, lead produces harmful effects in the neurologic, endocrine, renal, and haematological systems;^{1,5-7} however, even low levels are detrimental to the human body, and no safe level has been identified.⁶⁻⁸

Ingestion and inhalation are the major routes of entry, and children, particularly those under five,

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are the most susceptible.^{8,9} This is because they tend to explore the environment and put items in their mouth. Children also have a higher absorption rate of lead compared to adults.⁸

One in three children worldwide is exposed to lead, and children in low and middle-income countries are the most affected.¹⁰ Blood Lead levels (BLL) above 5 µg/dl are deemed elevated.¹¹ While 97% of children in the United States have BLL less than 5 µg/dl,¹² in many other parts of the world, the situation is different. Eighty per cent of children aged 36-60 months in Pakistan had BLL above 10 µg/dl,¹³ while a study in rural China found that 95% of children living in a lead-polluted area had BLL greater than 10 µg/dl.¹⁴ A recent study using data from the Global Burden of Disease database estimated that 765 million intelligence quotient (IQ) scores were lost by under-5 children due to lead exposure, with the majority of the losses occurring in low and middle-income countries¹⁵ where poverty, low household incomes and other adverse conditions put families at risk of increased exposure to lead.¹⁶ In 2019, China, India, Bangladesh, Indonesia and Pakistan were the top five countries with deaths from lead exposure in the world.¹⁷

In Africa, 58% of children in a rural area in Benin had BLL above 50 µg/l;¹⁸ a similar finding was reported in Cairo, Egypt, where over 50% of children had BLL greater than 10 µg/dl.¹⁹ In Dakar, Senegal, elevated lead levels were found among children in a community known for recycling lead batteries, with 18 of the children dying due to lead poisoning and elevated BLL values of up to 129.5µg/dl. Moody *et al.* in Uganda demonstrated that elevated lead levels were associated with stunting.²⁰ Lead has also been associated with poor neuro-developmental outcomes for infants of mothers exposed to lead in Tanzania.²¹ In Nigeria, the mean blood lead levels range between 10 µg/dl and 19 µg/dl. These values varied with location, parental

occupation and lead exposure. A recent study in Ile-Ife compared blood lead levels among children in a gold mining community with those of children in a non-mining community and found that all the children had lead levels greater than the stipulated 5µg/dl; however, children from the mining communities had a higher BLL (24.2±5.3 µg/dl) than those from non-mining communities (19.5±6.4 µg/dl).²² A recent New York Times report on Blood lead levels of residents in Ogiyo, a lead battery recycling community in Ogun State, Nigeria, disclosed that 7 in 10 residents had dangerously high levels, with values as high as 28.5 µg/dL recorded in one child.²³

Documenting the blood lead levels of children across different regions and communities of the country is essential, as this will provide data on the trend in BLL among children, thus adding to the body of data needed for advocacy and policy making. The present study aimed to determine the BLL of children aged 6-59 months seen at Federal Teaching Hospital, Ido-Ekiti with acute childhood ailments.

Methods

Study setting and design

This cross-sectional study was conducted at the Children's Outpatient Clinic of the Department of Paediatrics at the Federal Teaching Hospital, Ido-Ekiti (FETHI), from October 2021 to June 2022. The hospital provides care for children in Ekiti State; it also serves as a referral centre for facilities in the neighbouring Ondo, Kwara, Osun and Kogi States, with an average of 250-300 children attended to each month.

Ethical considerations

Ethical approval for the study was obtained from the hospital's ethics committee before commencement of the study. The approval number was ERC/2021/04/21/539A. Children

were recruited after their caregivers provided informed consent.

Sample size determination

Using a prevalence of lead levels > 10 µg/dl of 70% from a similar study, a sample size of 355 participants was calculated using Cochran's formula.

$$n = \frac{(Z_{1-\alpha/2})^2 P(1-P)}{d^2} \text{ where:}$$

n = sample size.

Z_{α} = Standard deviate at 95 per cent confidence level (1.96)

P = prevalence of lead level > 10µg/dl among children from a similar study²⁶ = 70%

d = degree of desired accuracy set at 0.05.

n = 323 subjects.

To make provision for a non-response rate of 10%, the minimum sample size was increased to 355.

Study population

Children aged 6-59 months seen at CHOP with common ailments such as malaria, upper respiratory tract infections, and gastroenteritis, whose parents provided consent, were purposively included in the study. In contrast, children with chronic illnesses and severe acute malnutrition were excluded.

Data collection

A pre-designed proforma was used to collect relevant data from the participant. Anthropometric parameters of the children were measured using standard methods, and 5 mL of blood was obtained from a suitable site after cleaning for the estimation of BLL. BLL was estimated using Graphite Furnace Atomic Absorption Spectrometric Methods and blood lead levels above 5µg/dl were deemed elevated.

Data analysis

Data was analysed using the Statistical Package for Social Sciences (IBM SPSS) version 23. Blood lead levels were compared across the age

groups and socioeconomic classes using an independent Kruskal-Wallis test, while mean BLL was compared between the two genders using the Mann-Whitney U test.

Results

Three hundred and sixty-three subjects were studied, comprising 179 (49.3%) males and 184 (50.7%) females, thus giving a male-to-female ratio of 0.97:1. The median (IQR) age was 25 (14-42) months (Table I).

The subjects' blood lead levels ranged from 0.1 to 22.8 µg/dl, with a median (IQR) of 5.10 (1.80-8.63) µg/dl. Median blood Lead level was higher in males, 5.35 µg/dl (1.80-8.85), than in females, 5.00 µg/dl (1.80-8.35), though the difference was not statistically significant (p=0.694). One hundred and eighty-three children (51.7 %) had blood Lead levels > 5 µg/dL. One subject (0.3%) had a value above 20µg/dl. There was no significant difference in BLL according to age, gender and socioeconomic class (Figures 1-3) Fifty-three per cent of subjects with BLL >5µg/dl were older than 24 months of age. There was no difference in the proportion of children with elevated BLLs by gender, as shown in Table III.

Sociodemographic factors associated with elevated lead levels

Storage of water in plastic containers, residence near a main road and use of toys with peeled paint were significantly associated with elevated lead levels, as illustrated in Table VI.

Discussion

The mean blood lead level in this study was 5.82 ± 4.51 µg/dL. This value is lower than those reported in other parts of the country.²⁶⁻²⁹ Fifty-two per cent of the subjects in this study had elevated levels above 5µg/dl. This is lower than the reported rates in Enugu²⁷ and Asaba²⁹, where 69% to 75% of subjects had BLLs greater than 5 µg/dL, respectively. In Benin City,²⁸ 79% of

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subjects had elevated levels despite using a higher cut-off point of 10 µg/dl. In Osun State, blood lead levels were elevated in 100% of participants. While the studies in Benin and Enugu were hospital-based, like the present study, the study in Asaba was school-based,

while that in Osun state was community-based. The difference in blood lead levels suggests that the degree of environmental lead pollution varies from location to location across the country.

Table I: Sociodemographic characteristics of the study participants

Characteristics	No of participants	Percentages
	(n=363)	(%)
Gender		
Male	179	49.3
Female	184	50.7
Age group		
6-12 months	77	21.2
13-24 months	104	28.7
25-36 months	72	19.8
37-48 months	56	15.4
49-59 months	54	14.9
Social classes		
Upper	253	69.7
Middle	98	27
Lower	12	3.3
Maternal Level of Formal Education		
No Formal Education	1	0.3
Primary	6	1.1
Secondary	47	12.9
Tertiary	285	78.6
Postgraduate	24	6.6
Paternal Level of Formal Education		
No Formal Education	5	1.4
Primary	3	0.8
Secondary	31	8.5
Tertiary	273	75.2
Postgraduate	51	14

Table II: Blood Lead levels of the study participants

Blood lead level	Frequency	Percentage
(n=354)		
<5µg/dl	171	48.20
5 - <10µg/dl	111	31.40
10 - <20 µg/dl	71	20.10
≥20 µg/dl	1	0.30

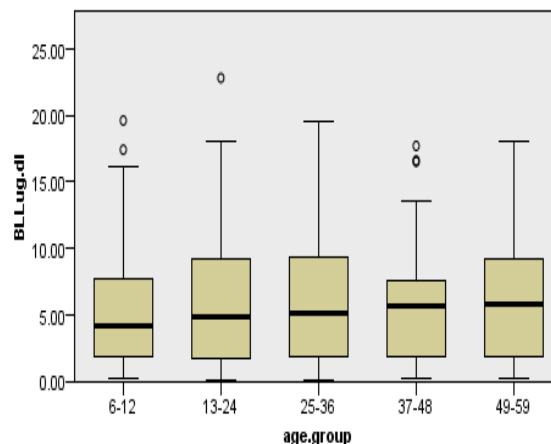


Figure 1: Independent Kruskal-Wallis test comparing blood Lead Levels across age groups. * Kruskal-Wallis H-test value: 0.764, p = 0.943. BLL - Blood lead level; No significant variation in BLL across age groups.**

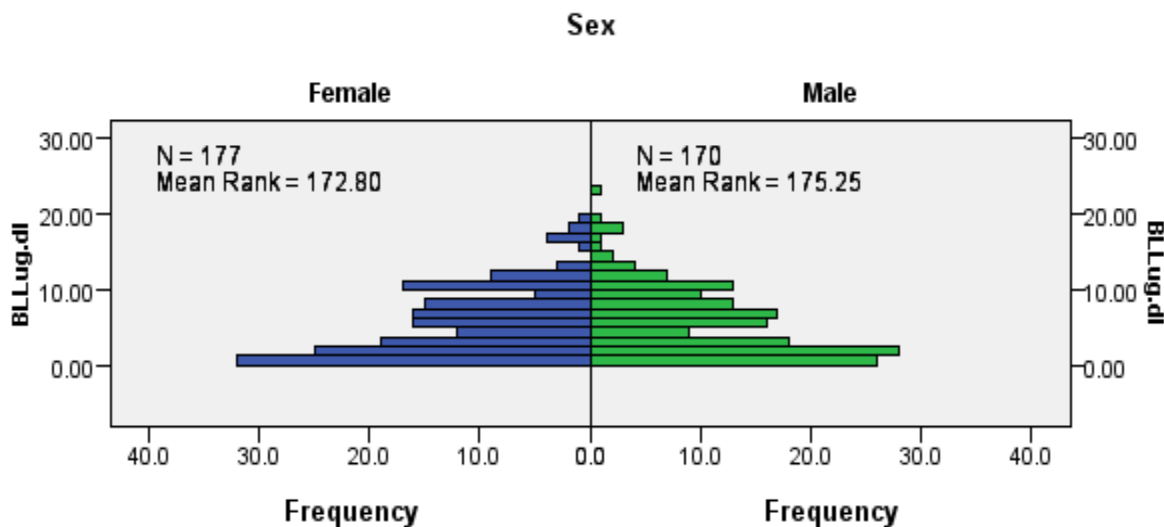


Figure 2: Independent samples Mann-Whitney U test comparing Blood lead levels according to gender, U-statistic: 14,833.00, p = 0.820. BLL - Blood lead level; No significant variation in BLL across gender.

Table IIIa: Status of Blood Lead levels according to age group, gender and socioeconomic class

Blood Lead Level	Age group (months) n = 354				
	6-12	13-24	25-36	37-48	49-59
<5µg/dl	40 (23.4)	52 (30.4)	33 (19.3)	23 (13.5)	23 (13.5)
≥ 5µg/dl	37 (20.2)	49 (26.8)	37 (20.2)	30 (16.4)	30 (16.4)

Blood lead level lower than what was found in this study was reported among children in Owerri

with a value of $2.38 \pm 3.6 \mu\text{g/dl}$.³⁰ Only 12.5% of the subjects had levels above 5µg/dl. It is

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possible that there is indeed a decline in blood level of children within the country, however geographical variations still appear to exist. A study done in Kano found that 42% of those in lead related occupation and 20% of those in non-lead related occupation had lead level above 10 µg/dL.³¹ Percentage of those with elevated lead levels was lower than found in this

study probably due to a higher cut-off point used for designating subjects with elevated lead levels in that study. In the United States of America, less than 2% of children less than 5 years of age have BLL of 5µg/dl ¹² showing that a lot of work still needs to be done to ensure decline in BLL of children in this environment.

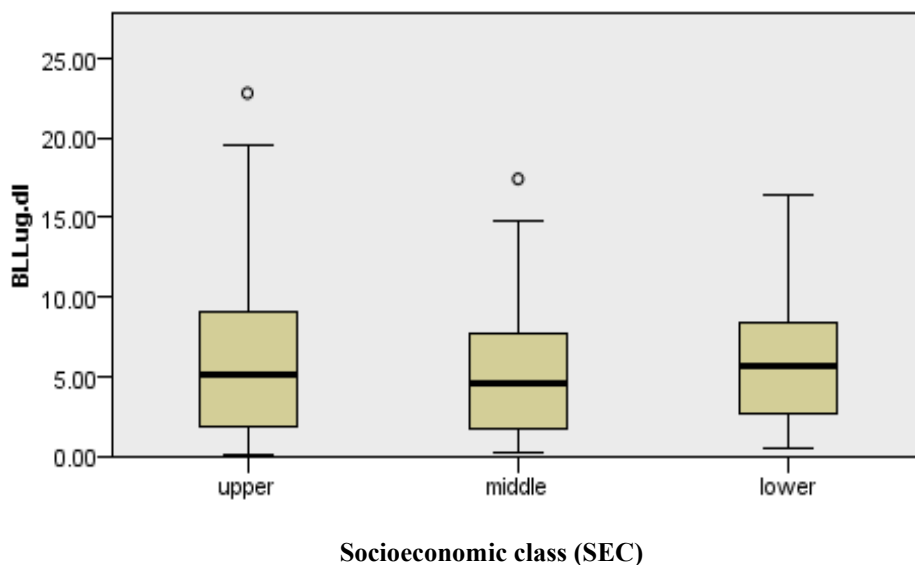


Figure 3: Independent Kruskal-Wallis test comparing blood lead levels across socioeconomic classes (SEC). Kruskal-Wallis H-test value: 0.934, p = 0.627. BLL - Blood lead level; No significant variation in BLL across SEC.

Table IIIb: Status of Blood Lead levels according to age group, gender and socioeconomic class

Blood Lead level	Gender	
	Male n (%)	Female n (%)
<5µg/dl	82 (48.0)	89 (52.0)
≥5µg/dl	92 (50.3)	91 (49.7)

Table IIIb: Status of Blood Lead levels according to age group, gender and socioeconomic class

Blood Lead levels	Socioeconomic Classes		
	Lower	Middle	Upper
<5µg/dl	5 (2.9)	49 (28.7)	117 (68.4)
≥5µg/dl	6 (3.3)	47 (25.7)	130 (71.0)

Table IV: Sociodemographic factors associated with elevated blood Lead levels

Factor	Odds Ratio	95% Confidence Interval		p-value
		Lower	Upper	
Method of Water Storage	0.57	0.27	0.98	0.04
Residence near the main road	0.45	0.23	0.9	0.02
Use of painted/coloured toys	0.83	0.44	1.57	0.08
Use of toys with peeled paint	0.12	0.01	0.98	0.05

Outside Nigeria, very high lead levels were reported in China,¹⁴ Pakistan,¹³ Egypt¹⁹ and Benin republic.¹⁸ These levels were often associated with parental occupational exposure to lead possibly due to the contamination of the soil and environment by lead, parent may also bring home contaminated clothing which may be a source of exposure. The possibility of in- utero transfer of lead may also be considered as demonstrated in Infants of artisanal mother in Tanzania. Most of the subjects in this study belong to the upper and middle class and exposure to occupational exposure such artisanal mining among parent is unlikely.

In this study, mean levels of lead were higher in the older age group and among boys, though this was not statistically significant. A similar finding was reported in Kaduna³² and Enugu,²⁷ where boys had a higher lead level. A possible explanation is the exuberantly active lifestyle of most male children compared to their female counterparts. In contrast, a study in Owerri³⁰ reported that lead level was higher in females.³⁰ Though it is not clear why this was so, their finding was also not statistically significant. This indifference is probably because the behavioural tendency of put objects in the mouth is similar in both genders at this age.

Storage in plastic containers, use of toys with peeled paint, and living near a major road were factors associated with elevated blood lead levels. Although the method of water storage was also found to be associated with elevated lead levels in Jos²⁶, other factors related to elevated lead levels in Jos did not contribute to them in this study. This may be due to variations in cultural practices in both regions. In Kaduna³² and Madagascar,³³ residence near a tarred road was associated with elevated lead levels, a finding similar to that in this study, where residence near a major highway was also associated with elevated lead levels. Commercial activities and vehicular movement are higher around major highways, with fumes from the exhaust of

vehicles, generators, etc. being released into the air. Fumes contain gaseous compounds of lead that can be inhaled and absorbed into the body.

Strengths and limitations

This study contributes to the body of evidence needed for policy-making, advocacy, and health education. This is a hospital-based study; however, a community-based research spanning both rural and urban areas may have better captured the various strata of the community. Assessment of environmental levels may help identify potential sources of contamination that were not examined in this study.

Conclusion

This study has determined the blood lead levels of children under five in Ekiti State, highlighting BLLs compared to other parts of Nigeria and other countries. More than half of the participants in the present study had blood lead levels above the recommended level of 5 µg/dL. Storage of water in plastic containers, residence near a main road and use of toys with peeled paint were significantly associated with elevated lead levels. At the same time, there was no difference in mean BLL values across age, gender, and socioeconomic status. There is a need for increased awareness about lead and its dangers. Government-sponsored screening may help identify communities at risk.

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