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BLOOD LEAD LEVELS IN APPARENTLY HEALTHY CHILDREN SEEN AT THE UNIVERSITY OF BENIN TEACHING HOSPITAL, BENIN CITY NIGERIA

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ABSTRACT

Background: In excess of tolerable blood levels, lead essentially a toxicant, is injurious to the CNS and other systems in man particularly children. The deleterious effects can occur in immediate or long term. Known predisposing factors in excessive blood lead levels (BLLs) are prevalent in Nigeria and unduly high BLLs have been noted in parts of the country. Values for Benin and its environ are not documented.

Objective(s): The objective of the study was to determine BLLs in apparently healthy children aged 1-15 years.

Subjects and Methods: Subjects were 89 (64.0%) males and 50 (34.0%) females drawn from upper social class, [105(75.5%)] and lower class [34 (24.5%)]. They were among children on routine follow up in the Consultant Outpatient Clinics of University of Benin Teaching Hospital, Benin City. BLLs were determined using Atomic Absorption Spectrophotometer.
Results: Of the 139, 111(79.9%) had elevated BLLs (eBLLs) (> 9 µg/dl). About 3% had BLL of >45 µg/dl. Prevalence of eBLLs was independent of gender, age and family socioeconomic status (SEC). Mean BLL (mBLL) in subjects was 19.24 ± 10.17 g/dl (range 8 – 53g/dl). This was uninfluenced by gender and age. However, mean value of 23.35+12.35 µg/dl obtained in children from lower SEC was significantly higher than (18.12+9.17 µg/dl) from those in upper SEC ($t=2.38$; $p=0.019$). None of the risk factors examined predicted eBLLs. Though mBLL was higher in obese compared to children who were of normal weight/overweight, nutritional status did not significantly influence mBLL.

Conclusions/Recommendations: Prevalence of eBLLs is children in Benin and its environ is sufficiently high to warrant immediate attention from stakeholders. This could include creation of awareness of the dangers of lead poisoning, policy changes regarding disposal of lead-laden materials and implementing other measures known to checkmate environmental leadpollution.

Keywords: *Blood, Lead, Children, Benin City.*

NTRODUCTION

Lead is of no known biologic value to man but purely a toxicant.[1] At unsafe blood levels it interferes with a variety of body processes/functions and causes toxicity to organs and tissues.[1] The nervous system is most sensitive to lead exposure as it interferes with its development causing neurotoxicity which manifests as cognitive dysfunction, decline in intelligence and non-verbal reasoning and short term memory. It can cause potentially permanent learning/behavioural disorders and encephalopathy.[2,3]

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Children compared to adults suffer more from the effects of excessive exposure to lead because they are rapidly growing and have developing brain. They absorb more lead than adults with the attendant increase in the per unit body weight. Children most at risk of developing problems from high blood lead levels (BLLs) are those aged 6 months to 6 years.[3-5]

Whole BLL of 10µg/dl is taken as the upper limit of normal. Beyond this level disproportionately higher number of children suffers from its deleterious effects. However toxicity can occur at lower levels.[6] Five µg/dl is recently proposed as reference value (based on 97.5 percentile cut off value from a large population study) in children less than 5 years.[1] Children at risk of toxicity include those of ethnic or racial minority groups who may be exposed to lead containing folk remedies, those from countries where lead

poisoning is prevalent, from low income families and who live in areas with > 12% of the children having blood lead levels >10µg/dl.[7] Other risk factors include preschool age, use of lead-laden cosmetics, and parents occupationally exposed to lead.[1]
Lead exposure is a common environmental problems in terms of number of persons exposed and the public health toll it exerts.[11] It affects over 890 000 children in the United States.[12] Over 30% and 7% of South and North American children respectively have BLLs in excess of 10µg/dl.[13] Although regulations reducing lead in products have greatly reduced exposure in developed world same cannot be said of developing countries.[11] About 35% of school children in Johannesburg evaluated by Mathee *et al* in 2002 had elevated BLLs. Peeling paint and pica were identified as the risk factors.[14]

Chronic exposure to lead in domestic settings occur through contact with lead-based paint, lead-contaminated water, food, motor batteries with its waste and inhalation of dust from aerosolized leaded gasoline. Some of these conditions are prevalent in Nigeria as the environment is highly lead laden due partly to poor government regulations of lead sources as well as uncontrolled sources of environmental lead contamination.[8,9] Nigerian children have been documented to have high prevalence of elevated BLLs.[10]

In Nigeria, like most developing countries, very little attention is paid to undue lead exposure. In 2010, cases of acute lead poisoning causing the death of over 400 children were recorded in Zamfara State.[1] Nriagu *et al* in 1997 noted a mean BLL of 10.6µg/dL among 87 children aged 1 - 6 years in Central Kaduna[15] whereas Pfitzner *et al* in 1997 in Jos, observed that 70% of the 218 children evaluated had BLL in excess of 10µg/dl. They noted that BLLs were higher in those who used eye cosmetics, tap water as source of drinking water or lived near a battery smelter.[16]

From the foregoing, it is obvious that issues of elevated BLLs is rampant in Nigeria with the enormity of the problem varying from one location to the other. There is paucity of data for children South-South Nigeria in general and Benin City in particular. This study therefore aimed at establishing the proportion of apparently healthy children in UBTH with elevated BLLs and the socio economic determinants.

SUBJECTS AND METHODS

The General Out-Patient Clinic (GOPC) of the University of Benin Teaching Hospital (UBTH), Benin City hosted the descriptive cross sectional study. UBTH is one of the first generation teaching health facilities in Nigeria providing all levels of care for inhabitants of Edo, Delta and neighbouring states.

Subjects were apparently healthy children aged 1-15 years without history of undue exposure to lead. A proforma (pre-tested and researcher administered) was used to obtain relevant information. (biodata, parent's occupation and level of education, associated risk factors and possible sources of lead exposure) from parents/guardians or the children whichever was appropriate. Family socio-economic stratification was carried out using Oyedeji[17] classification.

Anthropometry and BMI were evaluated using standard methods and these were plotted on the appropriate CDC/ WHO charts to determine subjects' nutritional status.
Using aseptic methods, 4 mls of venous blood was obtained from each child and transferred into a metal free, pre-labeled EDTA container. The whole blood samples were then stored at -20°C in the Institute of Child Health Research Laboratory. Fortnightly, samples in ice packs were moved to the Nigerian Institute for Oil Palm Research, (NIFOR) for blood lead estimation. Determination of blood lead levels was by the use of Atomic Absorption Spectrophotometer. (AAS, Varian Spectra AA10 model) using the methods described by Dogan *et al*[18]

The test results were made available to the study subjects and attending physician. Subjects with elevated blood lead levels were managed in accordance with established protocols.

The Ethics and Research Committee of the UBTH gave permission for the study while written informed consent/assent was obtained respectively from eligible parent/guardian or subject (for those were at least 10 years of age.

Data obtained were analyzed using SPSS version 20.0 Statistical software. Continuous data were summarized as mean (+SD), while categorical data were presented as proportions. Test of strength of association was done using Pearson's Chi-square and Fisher's Exact test where applicable.

Comparison of mean was done using t-test. Multiple Logistic Regression models were used to test for predictors of elevated BLLs. The level of significance of each test was set at $p < 0.05$ at 95% confident interval.

RESULTS

One hundred and thirty nine apparently healthy children were recruited for the study.

Characteristics of subjects

The socio-demographic characteristics of children are as shown in Table 1. There were 89 (64.0%) male and 50 (36.0%) female subjects, giving a male to female ratio of 1.8:1. The mean (± SD) age of the subjects was 6.45 ± 3.95 years. The modal age bracket was 1-5years (65/139 or 46.8%) while the least represented was 11-15 years (28/139 or 20.1%). Among the 139 subjects, 105/139 (75.5%) and 34/139 (24.5 %) were drawn from the upper and lower social classes respectively.

Prevalence of elevated blood lead levels in apparently healthy children according to gender, age group and socio economic status

One hundred and one of the 139 subjects had elevated blood lead levels. Comparable proportion of male (79.8%) and female (80.0%) subjects had elevated BLLs. Prevalence of elevated BLLs was independent of age and family socioeconomic class.

Classes of elevated blood of lead levels in the study population

The stratification of BLLs in the study population is as shown in Table II. Of the 139 subjects 110 had blood levels in excess of 9 g/dl. Most subjects (57/110 or 51.8%) with elevated BLLs had values in the range 20 - 44g/dl. Only four subjects had level 4 BLLs while none had markedly elevated values corresponding to level 5.

Mean blood lead levels

The mean ± SD blood lead level in the subjects was 19.24 ± 10.17 g/dl (range 8 – 53g/dl). Mean BLL in males of 19.35+10.63 was comparable to value in females (19.50+9.55g/dl). Mean blood lead level was also independent of age. However, children drawn from lower socio economic class had significantly higher mean BLL (23.35+12.35 vs 18.12 + 9.17 g/dl; t=2.38, p=0.019) compared to those from the upper class (table III).

Risk factors predicting the occurrence of elevated blood lead levels in subjects.

A number of factors ranging including habit, environmental and cultural practices were evaluated as possible risk factors for elevated BLLs. (table IV). However none was predictive of elevated BLLs.

Mean blood lead level of apparently healthy children according to nutritional status

Majority (123 or 88.5%) of the 139 subjects had normal weight. The distribution of the subjects according to nutritional status is as contained in table V. Mean blood lead level was higher in obese (23.75+11.44) compared to those with normal weight (19.50 + 10.43). Nonetheless, mean blood lead levels in subjects were independent of nutritional status.

Table I: Socio-demographic characteristics of the study subjects.

Socio-demographic features	AHC n=139 (%)
Age group (years)	
1-5	65 (46.8)
6-10	46 (33.1)
11-15	28 (20.1)
Gender	
Male	89 (64.0)
Female	50 (36.0)
Socio-economic status	
Upper	105(75.5)
Lower	34 (24.5)

AHC: Apparently healthy children

Table II: Prevalence of elevated blood lead levels in apparently healthy children according to gender, age group and socio economic status

Socio demographic Features	Elevated blood lead levels in AHC n=111(%)	χ^2	p value	OR(95% CI)
Gender				
Male (n=89)	71(79.8)	0.001	0 .975	1.00(0.42-2.34)
Female (n= 50)	40(80.0)			
Age (years)				
1-5 (n= 65)	51(78.5)	0.320	0.850	
6-10 (n= 46)	38(82.6)			
11-15 (n=28)	22(78.6)			
Social economic status				
Upper (n =105)	83(79.0)	0.020	0.864	0.80 (0.30-2.20
Lower (n = 34)	28(82.4)			

Table III: Mean blood lead levels in apparently healthy children according to gender, age group and socio economic status.

Socio-demographic Features	AHC µg/dl	t	*p value*
Gender			
Male (n=89)	19.35 ± 10.63	0.082	0.934
Female (n=50)	19.50 ± 9.55		
Age Group (years)			
1-5 (n=65)	19.57 ± 10.05	0.040	0.960
6-10 (n=46)	18.80 ± 10.25		
11-15 (n=28)	19.45 ± 10.76		
Socio economic class			
Upper (n=105)	18.12 ± 9.17	**2.38**	**0.019**
Lower (n=34)	23.35±12.35		

Table IV: Classes of blood of lead levels among the study population

Class of BLLs (µg/dl)	Subjects n=139(%)
Level 1 (=9)	29 (20.9)
Level 2 (10 – 19)	49 (35.3)
Level 3 (20 – 44)	57 (41.0)
Level 4 (45 – 69)	4 (2.9)
Level 5 (=70)	0 (0)

Table V: Risk factors predicting elevated blood lead levels in apparently healthy children.

Risk factor	n (%)	*p*	OR	95% C.I. for OR
Habit				
Finger sucking	6(5.6)	0.14	6.02	0.56 – 64.26
Pica	5(4.6)	0.12	0.09	0.00 – 1.94
Environmental				
Water storage	108(97.3)	1.00	1.00	0.55 – 1.83
House type	111(79.9)	0.48	0.73	0.30 – 1.75
Painted house	95(85.6)	0.62	0.69	0.16 – 3.00
Flaking paint	53(48.2)	0.16	1.94	0.77 – 4.87
Use of generator	92(82.9)	0.14	4.06	0.64 – 25.99
Flat level	61(54.9)	0.90	0.95	0.40 – 2.25
House location	42(37.8)	0.31	1.13	0.89 – 1.43
Others				
Use of eye cosmetics	1(0.9)	0.24	8.08	0.24 – 271.15
Use of toys	30(27.0)	0.42	1.24	0.74 – 2.10

Table VI: Mean blood lead level of apparently healthy children according to nutritional status

Nutritional Status	Number of subjects n(%)	Mean BLL (µg/dl)
Normal	123(88.49)	19.50± 10.43^{a}
Overweight	12(8.63)	17.00 ± 7.83^{b}
Obese	4(2.88)	23.75± 11.44^{c}

F=1.770, p=0.421; a vs b: t=0.081, p=0.421; a vs c: t=0.800, p=0.425; b vs c: t=1.339, p=0.202

DISCUSSION

Based on the widely acknowledged CDC set cut off value of $\geq$10 µg/dl of BLLs that may be deleterious to humans, comparable proportions of male and female children in the study had elevated BLLs suggesting that the risk of elevated BLLs is independent of gender. This finding is corroborated by the fact that mean BLLs were also comparable in both sexes. Gender is not a reported risk factor for increased lead exposure. Other known factors implicated in undue exposure to lead are also gender independent.[1]

Elevated BLLs were observed in the various age brackets in comparable proportions. Activities more prevalent in preschool children have been implicated as major determinants of elevated BLLs. [1] This assertion is however, not supported by findings from this study. Mean BLLs were comparable across the different age brackets. The propensities of finger sucking and mouthing of substances and pica were found not to play any role in the prevalence of elevated BLLs in the study. With improved socio-economic development driven by improved parental education, as witnessed in recent times in Nigeria, prevalence of such habits are bound to wane as corroborated by the fact that less than 4% of the study subjects were associated with pica and finger sucking. This may explain the reduced importance of these factors in the prevalence of elevated BLLs in the study locale.

That as many as four in every five preschool children had elevated BLLs is nonetheless worrisome. Undue exposure to elevated lead early in life could be associated with grave consequences later. Cases of poor cognition, predisposition to violent crimes and social maladjustments noticeable later in adolescence have been traced to increased blood lead levels that occurred early in the lives of the individuals concerned.[1] These effects are due perhaps to the fact that increased blood causes impaired development of tertiary neuronal structures.[1]

Comparable proportions of children drawn from upper and lower socio economic classes had elevated BLLs. This observation is in contrast to the acknowledged role of poverty as a risk factor in the prevalence of elevated BLLs.[1] In developed economies house type inhabited by children and their parents and the location of such houses are functions of the family socio economic stratification. In such economies poor families live in old dilapidated houses characterized by flaking paints laden with lead.[1] In our environment the society is not well organized and persons of different social classes can live side by side. Old houses are commonly without paint and those painted are left stale for long and the paints do undergo flaking.[19] The finding may also be a reflection of the fact that factors playing dominant roles in the prevalence of elevated BLLs are not compartmentalized as may happen with dust laden with lead.

In terms of degree of exposure however, children drawn from low socio economic class families had higher mean values than those from high social class families perhaps underscoring the fact that outside environmental pollution with lead, children from low socio economic class families may be involved in some other endeavours that are predisposing them to increased BLLs. Activities like scavenging, disposal of leaded waste and handling of materials laden with lead as seen recently in the study locale are more likely to be rampant with the children and adults from poor socio economic back grounds.

In 2010, prompted by the reports of Doctors Without Borders the WHO and the CDC were to discover that several villages in northern Nigeria had elevated BLLs arising from lead dust derived from illicit ore mining for gold by adults.[1] Children were not directly involved in the mining but the activity itself caused environmental lead pollution.

Only one seventh of the children had values of blood lead hitherto considered as within safe limits. But with the realization that the cut off of 10 microgram per dl is neither predictive nor indicative of toxicity or when deleterious effects of increased BLLs would become symptomatic the CDC recently instead opted for the use of 5 microgram per dl based on the 97.5 percentile of blood lead level distribution in a large population of children.[1] This would imply a higher proportion of our subjects as having BLLs outside the range of safe margin. The direct implication of our finding is that a substantial proportion of the study subjects are lead exposed. They may not have overt features of toxicity but sub clinical manifestations of lead poising may be prevalent. Values of BLLs of 100 microgram per dl known to be associated with lead encephalopathy and other serious morbidities were not seen in the subjects.

In recent past economies are known to have taken measures that caused marked reduction in environment lead. A leading intervention known to have achieved this is the discontinuation of use of leaded gasoline: occasioned by international treaties and regulations.[1] In economies where it was implemented drastic reduction in blood lead levels in the inhabitants were noticed over time.[1] Nigeria is reported to have implemented the policy before now. That many persons still have elevated BLLs, some considered very high, may well suggest that other important risk factors relevant in lead poisoning are still operational. Parental occupation like peasant mining, scavenging, indiscriminate disposal of waste materials containing lead as found in second hand electronics may be important in these regards.

Higher mean BLLs were observed in obese children compared to those that were overweight or had normal weight. Reasons why obese children should have increased values compared to others are not readily apparent. Elevated BLLs have been implicated in reduced height later in life[1] but there is paucity of studies that examined relationship(s) between blood lead levels and weight.

In conclusion, blood lead values warranting direct intervention were not encountered in the study. However, interventions such as health education on the sources of environmental lead pollution and dietary/life style modifications could find relevance in the bid to reduce blood lead levels particularly in children. Practices that contribute to increased lead pollution need to be identified and modulated by relevant agencies of government.

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