DOI: 10.7860/JCDR/2021/48930.15297

Original Article

Paediatrics Section

Paediatric Blood Lead Levels and its Correlation with Anaemia: A Study from Central India

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ABSTRACT

Introduction: Lead is a toxic element used commonly in many products like lead-acid batteries, paints, toys etc. Young children are particularly vulnerable to lead poisoning because of higher absorption capacity in comparison of adults. Safe level of lead exposure has to be established yet. Literature suggests a threshold lead level of 20-40 µg/dL for a decrease in haemoglobin in children.

Aim: To assess the correlation between Blood Lead Levels (BLL) and anaemia in children.

Materials and Methods: This cross-sectional study was conducted in a Paediatric Tertiary Care Hospital of Gwalior, Madhya Pradesh, India, during the period of May 2019 to September 2020. A 81 children between one to five years of age were included in study. Information was collected regarding general profile of the children and other parameters like socio-economic status (Modified Kuppuswamy scale), history of pica, application of surma, type of toys used, scholastic performance and somatic symptoms. Routine blood investigations were done including Haemoglobin (Hb) and BLL through venous blood sampling. BLL were done at Defense Research and Development Establishment (DRDE) Gwalior. Data entry was done in Microsoft Office Excel 2010 and analysed using Statistical Package for the Social Sciences (SPSS) software version 21.0. Chi-square test with Yates correlation was applied and p-value <0.05 was considered statistically significant.

Results: Among 81 study subjects, 53 were males and 28 were females. Total 48 (59.2%) children had Hb <11 gm/dL, 42 (51.8%) children had BLL <5 µg/dL and 32 (39.5%) had BLL between 5-10 µg/dL. There were 9% children (n=7) with BLL more than 10 µg/dL and none beyond 15 µg/dL. In the children it was found to have BLL ≥5 µg/dL, 20 children had Hb levels between 7-11 gm/dL whereas 19 had Hb levels above 11 gm/dL. No statistically significant association was found between the BLL and childhood anaemia.

Conclusion: This study did not show any relationship between BLL and Hb in children of age one to five years. Scarcity of diagnostic tools for detecting BLL and lack of public awareness regarding the probable sources of lead and its complications may result in missing the diagnosis.

Keywords: Children, Development, Haemoglobin

INTRODUCTION

Lead is one of the most common toxic elements of environmental origin. It is widely used in many products such as lead-acid batteries, pigments, paints, solder, stained glass, lead crystal glassware, ammunition, ceramic glazes, jewellery, and toys and in some cosmetics and traditional medicines [1]. From a particular source, young children absorb more lead as compared with adults [2]. Scientific evidences show that BLLs even below 10 µg/dL are associated with adverse cognitive, behavioural, attention problems, language difficulties and other toxic effects in infants and children [3,4]. Identification of lead poisoning is difficult at an early stage as the symptoms are non specific and mimic that of the other disorders, thus patients receive only symptomatic treatment [5]. Under-nourished children absorb more lead, making them more susceptible [2]. No safe level of lead exposure has so far been established [1].

The Centre for Disease Control (CDC) and the American Academy of Paediatrics (AAP) currently use the reference value of 5 µg/dL instead of the previous level of ≥10 µg/dL in community settings after recommendation by an expert committee in January 2012 on the basis of neurological toxicity [6-8]. It has been revealed by a number of studies that more than half the children in India have BLL ≥10 µg/dL [9,10]. Elevated BLL ≥10 µg/dL have been observed and found significantly associated with moderate and severe anaemia after accounting for other factors influencing anaemia [11]. According to National Family Health Survey (NFHS)-4 (2015-16) 58.6% Indian children between age 6 to 59 months are anaemic (Hb <11 g/dL) [12]. The Environmental Protection Agency has suggested a threshold lead level of 20-40 µg/dL for a decrease in Hb in children, although a clear cut-off is not defined and needs further studies to support through data [13]. This study has been conducted to assess any correlation between BLL and paediatric anaemia along with considering impact of various socio-demographic, economic and other factors on lead poisoning.

MATERIALS AND METHODS

This cross-sectional study was conducted in a private Paediatric Tertiary Care Hospital at Gwalior, Madhya Pradesh, India, during the period of May 2019 to September 2020. The study followed all the ethical principles for medical research involving human subjects, according to the Declaration of Helsinki.

Inclusion criteria: Children between one to five years of age who visited the study clinic during the study period and were managed on outdoor basis were included in this study.

Exclusion criteria: Children falling out of age criteria, diagnosed with haemolytic anaemia or any acute illness requiring admission and those unwilling to participate in the study were excluded from the study.

Study Procedure

Total 81 children showing clinical signs of anaemia were recruited as study participants by simple random sampling after obtaining informed written consent from their parents. Information was collected over a predesigned peer-reviewed proforma regarding general profile of the child and other parameters like socio-economic

status based on modified Kuppuswamy scale [14], history of pica, application of surma, type of toys used, scholastic performance, somatic symptoms like tiredness, headache, decreased play activity, decreased appetite, abdominal pain, behavioural symptoms like restlessness, destructive activities, violent behaviour, irritability, stealing, bullying, thumb sucking, type of house paint and use of cosmetics. Cronbach's alpha value for this questionnaire was 0.741. All study subjects went through general and systemic examination including anthropometry. Routine blood investigations were done including Hb and BLL through venous blood sampling. BLLs were done at DRDE, Gwalior.

STATISTICAL ANALYSIS

Data entry was done in MS office excel 2010 and analysed using SPSS software version 21.0 (trial version). Simple Linear Regression analysis was done for correlation between Hb and BLL. Chi-square test of independence with Yates correction was applied. The p-value <0.05 was considered statistically significant.

RESULTS

Among 81 study subjects, 54 (66.7%) were males and 28 (33.3%) were females. Among all the children, 28 (34.5%) were from rural areas in comparison to 53 (65.5%) urban children. About one third (34%) of the studied children belonged to lower middle and upper lower category of socio-economic class (Chi-square test of independence with Yates correction; p-value: 0.049491). Total 48 (59.2%) children had anaemia as per World Health Organisation (WHO) cut off for anaemia i.e., Hb <11 gm/dL. 18 (22.2%) children had a history of pica, however 65 (80.2%) had a history of regular application of Surma and 37% of them had BLL ≥5 µg/dL (Chi-square test of independence with Yates correction; p-value: 0.000641). Majority (56) of the children were regularly exposed to plastic toys. Parents were asked to talk about their children's school performance and 13 (16%) admitted their poor performance and majority (68%) were unaware about it. Relation of selected baseline characteristics to BLL in studied children has been shown in [Table/Fig-1].

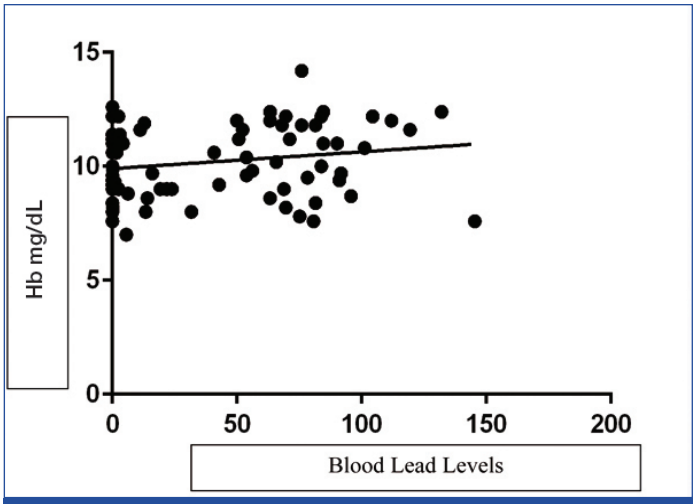
Parameter	BLL <5 µg/dL n (%)	BLL ≥5 µg/dL n (%)	Total n (%)
Sex			
Male	30 (37)	23 (28.4)	53 (65)
Female	12 (14.8)	16 (19.7)	28 (35)
Area			
Rural	16 (19.7)	12 (14.8)	28 (34.5)
Urban	26 (32)	27 (33.3)	53 (65.5)
Socio-economic status (Modified Kuppuswamy scale)			
Category-1	01 (1.2)	01 (1.2)	2 (2.4)
Category-2	10 (12.3)	09 (11.1)	19 (23.4)
Category-3	23 (28.3)	18 (22.2)	41 (50.6)
Category-4	09 (11.1)	10 (12.3)	19 (23.4)
Category-5	Nil	Nil	Nil
Pica			
Yes	12 (14.8)	10 (12.3)	22 (27.1)
No	28 (34.5)	29 (35.8)	59 (72.8)
Surma application			
Yes	31 (38.3)	30 (37)	61 (75.3)
No	11 (13.5)	08 (9.8)	20 (24.7)
Plastic toys	31 (38.3)	25 (44.6)	79 (98)
Poor school performance			
Yes	07 (8.6)	06 (7.4)	13 (16)
No	31 (38.3)	33 (40.7)	64 (79)

[Table/Fig-1]: Relation of socio-demographic characteristics and other contributory factors with Blood Lead Levels (BLL) (n=81).

A 42 (52%) children had BLLs <5 µg/dL and 32 (40%) had BLLs between 5-10 µg/dL, 7 (8.6%) children had BLLs more than 10 µg/dL and none beyond 15 µg/dL. In the children found to have BLLs ≥5 µg/dL, 20 (48.8%) children had Hb levels between 7-11 gm/dL whereas 19 had Hb levels above 11 gm/dL. None of the studied child had severe anaemia i.e., Hb <7 gm/dL. As per the observations of this study, no statistically significant association was found between the BLL and childhood anaemia [Table/Fig-2]. Linear regression analysis for Hb levels of studied children in relation to their BLLs have been plotted in [Table/Fig-3], which suggests no obvious relationship of Hb levels with BLLs. Relation of selected clinical characteristics to BLL in the studied children has been shown in [Table/Fig-4]. Tiredness, decreased appetite, irritability, restlessness/hyper activity were significant findings among children with BLL ≥5 µg/dL.

Anaemic status	Low BLL (<5 µg/dL)	High BLL (≥5 µg/dL)	Total (n)
Anaemic (Hb <11 gm/dL)	28	20	48
Non anaemic	14	19	33
Total	42	39	81

[Table/Fig-2]: Association between Blood Lead Levels (BLL) and childhood anaemia. The Chi-square statistic with Yates correction is 3.3011; The p-value is 0.069234. Not significant at p<0.05



[Table/Fig-3]: Linear regression analysis for relationship of haemoglobin and Blood Lead Levels (BLL).
Goodness of Fit 0.03749, R2 1.534, p-value 0.0853 (Not significant), Equation: Y =0.007376*X + 9.902

Clinical characteristic	BLL <5 µg/dL n (%)	BLL ≥5 µg/dL n (%)
Tiredness	15 (35.7)	15 (37.5)
Headache	02 (4.7)	04 (10)
Decreased play activity	31 (73.8)	13 (32.5)
Decreased appetite	17 (40.4)	18 (45.5)
Abdominal pain	10 (23.8)	04 (10)
Restlessness/Hyper activity	14 (33.3)	14 (35)
Destructive activity	06 (14.2)	06 (15)
Irritable	29 (69)	21 (52.5)
Violent behaviour	07 (16.6)	04 (10)
Thumb sucking	04 (9.5)	04 (10)

[Table/Fig-4]: Clinical characteristics in relation to different Blood Lead Levels (BLL). BLL <5 µg/dL (n=42); BLL ≥5 µg/dL (n=39)

DISCUSSION

This study was done to estimate BLL in children and to study its correlation with various attributes including Hb. Total 49% of children under this study were found with BLLs greater than or equal to 5 µg/dL which is in accordance with the findings of previous similar studies done at Jammu, New Delhi and Nagpur.

Cut-off value of BLL for these studies was 10 µg/dL [9,10]. In the present study, like the previous ones from Delhi and Mumbai, demographic variables such as education and gender did not associate with BLL [15].

In an Indian study, after adjustment for child's age, breastfeeding duration, standard of living, parent's education and occupation, maternal anaemia and number of children in the immediate family, children with lead levels >10 µg/dL were 1.3 times as likely to have moderate anaemia as children with lead levels <10 µg/dL. Similarly, the odds ratio for severe anaemia was 1.7 [11]. Present study does not indicate any association between BLL and childhood anaemia.

Another study conducted among 12 primary schools in Chennai tested the hypothesis that Transferrin (TF) C2 polymorphism modifies the effects of lead and Hb on intelligence and found a significant interaction between lead and Hb with the C2 variant. Children with TF C2 variant are more prone to the neurotoxic effects of lead while being less protected by higher levels of Hb [16].

In another similar study done at Delhi and Mumbai, no association was found between anaemia and BLL in Delhi (p=0.6) however statistically significant association was found between the two parameters in Mumbai (p=0.01). Cut off value of BLL for these studies was 10 µg/dL. Authors concluded that in such a situation, it may be difficult to say whether iron deficiency anaemia is linked to higher lead levels or not [17].

A low standard of living correlated with a 32.3% increase in BLLs [15]. Lead levels >10 µg/dL have been observed significantly associated with increasing age, duration of breastfeeding, a lower standard of living, a low educational status of parents and a greater number of siblings [11]. The stronger associations between cognition and cortical volume in children from low income families living in high lead risk tracts suggest that children can be greatly benefited from environmental adversity with reductions in environmental insults associated with lead exposure risk [18]. About one third of the index study subjects belonged to lower middle and upper lower category of socio-economic class as per Modified Kuppuswamy scale having BLL ≥5 µg/dL.

Literature suggests that young children are more vulnerable to lead poisoning due to higher capacity to absorb ingested lead from a given source than adults [2]. Their innate curiosity results in their mouthing and swallowing lead containing or lead coated objects. This psychological disorder called pica is magnified in children, who may, for example pick away at, and eat, leaded paint from walls, door frames and furniture. In Nigeria, Senegal and, other countries, exposure to lead contaminated soil and dust resulting from battery recycling and mining has caused mass lead poisoning and multiple deaths in young children [19]. In the present study, only 27% children had a history of pica out of which only 12% had BLL ≥5 µg/dL.

Surma, which is an ore that is mined and ground into a powder, being used for centuries as a cosmetic and to ward off evil in children as well as women. In the absence of manufacturing regulation, its lead content varies greatly, from 16-70% and traditionally surma use in eyes of children has been a popular practice in India [20]. A study was conducted in Kolkata with objective of regular surma application in eyes of children and its association with BLLs and anaemia. Same study also assessed lead content of different types of surma and found high lead levels in all samples of surma except the white one (out of total 34 samples of black, brown, orange, grey and white varieties of surma). The mean blood lead concentration of 69 surma user children was found to be 29.6±10.2 µg/dL whereas non user's value was 4.9±0.8 µg/dL. Low Hb levels were also observed in the users (10.2±1.4 g/100 mL) [21]. In present study, three-fourth of the children had a history of surma application in eyes regularly and 37% of them had BLLs ≥5 µg/dL which is highly significant (p-value 0.000641).

Majority of the studied children were exposed to plastic toys and 25 (44.6%) of them had BLL greater than or equal to 5 µg/dL. In a community based cross-sectional study of 297 children aged six months to six years in Nagpur, the authors assessed the prevalence of elevated (>10 µg/dL) BLL, their risk factors, and the lead contents in potential environmental sources. Analysis of various environmental sources such as paint, pencils, crayons, and clay revealed high lead levels and prevalence of elevated BLL in exposed subjects was observed as 67%. The results of such studies demonstrate the existence of a major environmental health problem among Indian children [10]. However, in the present study, no statistically significant association of exposure to plastic toys and BLLs in children was identified.

Symptoms of lead intoxication may be subtle and mimic other disorders. The general symptoms of lead poisoning include abdominal pain, vomiting, weakness, dizziness, body aches, loss of appetite, anxiety, encephalopathy, dementia, seizures, and coma [5]. Present study observed and analysed symptoms like tiredness, headache, decreased play activity, decreased appetite, abdominal pain, restlessness, hyperactivity, destructive activity, irritability, violent behaviour and thumb sucking. Sufficient evidences have supported that BLL even <5 µg/dL in children are associated with increased diagnosis of attention related behavioural problems and decreased cognitive performance as indicated by lower academic achievement, decreased Intelligence Quotient (IQ), and reductions in specific cognitive measures [22].

Limitation(s)

This study was done involving children attending paediatric clinic for minor illnesses. Due to time and resource constraints subjects could not be assessed for other toxic effects of raised lead levels like IQ and developmental anomalies. The findings are affected by variability and hence cannot be applied for the entire population from which the sample is drawn. In future the authors would like to extend this research further at institutional level or in the field involving larger population that could give more generalisable findings for the entire population.

CONCLUSION(S)

This study did not show any relationship between BLL and Hb in one to five years children. However, 49% of studied children attending routine outdoor clinic have been observed with BLLs ≥5 µg/dL which is an alarming situation in a resource limited country. Scarcity of diagnostic tools for detecting BLL and lack of public awareness regarding the probable sources of lead and its complications may lead in overlooking lead poisoning. Data needs to be procured through further studies to identify serious consequences of lead poisoning in children, particularly affecting their brain development and nervous system. This data will help in developing strategy regarding appropriate therapeutic interventions in affected population.

Acknowledgement

Defence Research and Development Establishment, Gwalior, Ministry of Defence, Govt. of India for processing blood samples to procure BLL. Dr Shubhanshu Gupta, Assistant Professor, Community Medicine, GMC Datia for support in statistical analysis.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 01, 2021
- Manual Googling: Jul 03, 2021
- iThenticate Software: Jul 23, 2021 (23%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Feb 09, 2021**
Date of Peer Review: **Apr 24, 2021**
Date of Acceptance: **Jul 06, 2021**
Date of Publishing: **Aug 01, 2021**