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Original Research Article

Prevalence of elevated blood lead level in children with global developmental delay and its relation with parental and child attributes

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ABSTRACT

Background: Lead, a potential neurotoxin, is found in soil, water and air as a result of its non-biodegradable nature. Common sources of lead toxicity in children are household paints, leaded pipes for water supply, canned food, coloured toys, herbal/folk remedies and electronic wastes. Along with this, other child and parental attributes have been found to contribute to elevated blood lead level (EBLL). Objectives were to estimate the prevalence and risk factors of EBLL in children with global developmental delay (GDD).
Methods: This hospital based cross sectional study was conducted between October 2019 and October 2021 at department of paediatrics of JNMCH, AMU, Aligarh. Data regarding clinical and sociodemographic characteristics as well as parental attributes was collected and entered on pre-designed proforma.
Results: Among 94 children with GDD mean BLL was found to be 6.72±6.46 mcg/dl and in their mothers it was 6.74±6.46 mcg/dl (p=0.984). A high prevalence of EBLL (>5 mcg/dl) in children with GDD (53.20%) and their mothers (49.3%) was noted. Various child and parental attributes were identified as potential sources of exposure to lead.
Conclusions: A high prevalence of EBLL in children with GDD in our study area might also suggest higher exposure from environmental sources such as soil, water, electronic waste, lead acid batteries, etc. For countries like ours which is rapidly undergoing industrialisation, these potential sources need to be identified promptly and swift action in this regard is needed in addition to preventive measures at personal and family levels.

Keywords: EBLL, GDD, Lead, Neurotoxin

INTRODUCTION

The global burden of developmental delay is enormous, with around 200 million children failing to attain their expected development in the first five years of life.[1] In India, the burden of developmental delay is around 10% in early childhood. Children with developmental delay pose a significant diagnostic and therapeutic challenge for caregivers and health care personnel. The United Nations sustainable developmental goals (SDGs) from 2015 to 2030 emphasizes upon the attainment of improved health status of children much beyond their mere survival.[2] Early development of a child results from a unique interplay between internal constitutional factors and external environmental exposures.[3]

Lead, a potential neurotoxin, is extensively found in soil, water and air as a result of its non-biodegradable nature. Lead toxicity can result through exposure of the child to lead via multiple sources. The resulting multi systemic manifestations range from anemia, abdominal symptoms, and intellectual disabilities to behavioural and psychological derangements. The social and demographic factors affecting blood lead level have been extensively studied and modified accordingly in many countries. However, in India and other developing countries, the corrective measures are only being slowly applied. In our extensive literature review, we could not find a study of blood lead level and sociodemographic associations in children with GDD from our part of the world. Aligarh and surrounding areas, being the hub of various industries like locks making, knobs, polishing, battery repair etc., are feared to be homes to children with risk of exposure to lead. The present study was designed to study blood lead levels in children with GDD and to explore the possible sociodemographic associations.

METHODS

This hospital-based cross-sectional study was conducted in paediatric out patient department, district early intervention centre (DEIC) and nutritional rehabilitation centre (NRC) of Jawaharlal Nehru medical college and hospital, Aligarh Muslim university, Aligarh between October 2019 and October 2021. Children with GDD aged 6 months to 5 years along with their mothers were enrolled in the study after due consideration of inclusion and exclusion criteria.

Data regarding clinical and sociodemographic characteristics and parental attributes was documented in a predesigned semi-structured proforma. Blood sample was collected from children and their mothers for estimation of blood lead and hemoglobin levels.

Sample size

The following formula for estimating prevalence was used to calculate the sample size:

$n=Z^2P(1-P)/d^2$

Where, n: required sample size, Z: Statistic corresponding to the level of significance (1.96 for 95% CI), P: Expected prevalence, d: Absolute error or precision. Considering the prevalence of EBLL of 9%[4] and precision of 5%, the sample size obtained was 130. However, due to situations arising out of COVID-19 pandemic, required sample size could not be achieved and the study was performed with 94 participants.

Inclusion criteria

Children from 6 to 60 months of age with developmental delay in at least 2 domains were included in study.

Exclusion criteria

Children with any of the following characteristics were excluded from the study-Sick children requiring admission and children receiving various supplements like calcium, zinc and iron.

Ethics

The study was approved by the institutional ethics committee, Jawaharlal Nehru medical college and hospital (JNMCH), Aligarh Muslim university (AMU), Aligarh. Written informed consent for participation in the study was obtained from parents/guardians.

Data management and analysis

Statistical analysis was done using the Statistical Package for Social Sciences (IBM SPSS version. 20.0) Software for Windows. For categorical data, we used frequencies and percentages with 95% CIs for description and the Pearson chi-square test was used for studying associations. For normally distributed continuous data, description was done using the mean and standard deviation (SD), while Student's t-test and One way ANOVA was used to compare mean between two groups and more than two groups, respectively. For continuous data that were not normally distributed, Mann-Whitney test or Kruskal Wallis test was used.

RESULTS

This hospital based cross sectional study was conducted at the department of paediatrics, JNMCH, AMU, Aligarh to estimate the level of blood lead level in children with GDD. The mean age of study subjects was 26.8±12.0 months. Most of the study subjects belonged to 13 to 24 months age group (38%) followed by 25 to 36 months age group (27.7%). Males constituted 68% of total participants. A total of 64 (68%) children belonged to rural locality followed by urban (18%) and peri-urban (14%) areas.

The prevalence of EBLL defined as blood lead level >5 µg/dl in children with GDD and in mothers enrolled by us was found to be 53.2% and 49.3% respectively. The sociodemographic profile and mean blood lead level in various subgroups is presented in Table 1.

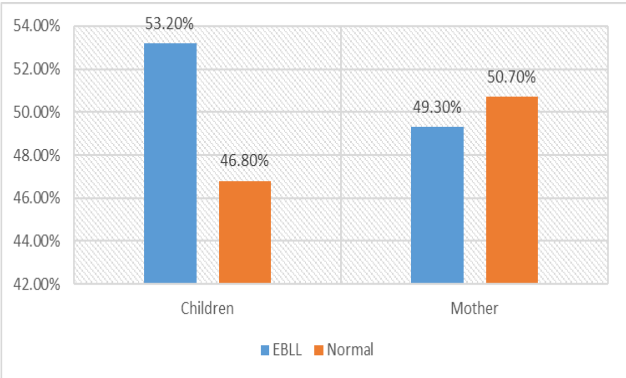

Figure 1: Prevalence of EBLL.

There was no significant difference in blood lead levels with regards to age, gender, religion, place of residence, use of unpurified water, cooking fuel used, age of house, recent painting of house or residence near traffic prone area (p>0.05, Table 1).

The mean blood lead level was considerably higher in children residing in kaccha house as compared to those in pakka house (11.18±7.16 vs 6.41±5.29 µg/dl), however this difference did not reach the level of significance at 95% confidence interval (p=0.068).

Child attributes and blood lead level

Child attributes and blood lead levels in the respective subgroups is shown in Table 2. Regarding child's attributes, use of kohl, pica, thumb sucking, pets in house, use of colour toys and history of eating from roadside vendors were not associated with a higher blood lead level (Table 2).

Table 1: Sociodemographic profile and blood lead levels.

Variables	N (%)	Mean BLL ± SD (µg/dl)	95% CI	P value
Age-group (In months)				
6 to 12	13 (13.8)	7.97±6.07	4.99-11.43	0.82
13 to 24	36 (38.0)	6.02±5.49	4.27-7.70	
25 to 36	26 (27.7)	7.25±5.94	4.85-9.62	
37 to 48	17 (18.1)	6.49±4.94	4.90-8.71	
49 to 60	2 (2.1)	6.00±1.08	5.23-6.77	
Gender				
Male	64 (68.1)	6.24±5.09	4.97-7.47	0.21
Female	30 (31.9)	7.75±6.27	5.71-9.95	
Religion				
Hinduism	68 (61.7)	6.49±5.40	5.06-7.79	0.61
Islam	36 (38.3)	7.09±5.73	5.49-9.42	
Residence				
Urban	17 (18.1)	6.18±4.81	4.09-8.97	0.88
Rural	64 (68.1)	6.77±5.83	5.06-8.33	
Peri-urban	13 (13.8)	7.15±5.00	4.63-9.65	
Use of water				
Purified	01 (1.07)	5.10	5.10-5.10	0.92
Unpurified	93 (98.93)	6.73±5.33	5.79-7.64	
Kerosene as a fuel for cooking				
Yes	03 (3.19)	2.98±1.16	2.10-4.30	0.25
No	91 (96.81)	6.84±5.55	5.92-7.80	
Type of house				
Pakka	68 (72.34)	6.41±5.29	5.57-7.90	0.06
Kaccha	26 (27.66)	11.18±7.16	4.78-9.43	
How old is the house (In years)				
<15	56 (59.57)	6.88±5.81	5.56-8.25	0.96
≥15	38 (40.42)	6.47±5.08	4.67-7.77	
House painting done (In years)				
≤5	19 (20.21)	6.09±5.86	3.44-8.38	0.37
>5	75 (79.79)	6.88±5.44	5.88-7.87	
Residence in proximity to traffic congestion (km)				
≤0.5	26 (27.66)	6.22±5.18	4.51-8.39	0.58
>0.5	68 (72.34)	6.91±5.56	5.32-8.50	

Table 2: Child attributes and blood lead levels.

Child attributes	N (%)	Mean BLL ± SD (µg/dl)	95% CI	P value
History of pica				
Present	21 (22.34)	7.84±7.10	4.17-10.89	0.68
Absent	73 (77.66)	6.39±4.96	5.44-7.61	
History of thumb suckling				
Present	49 (52.13)	7.10±5.72	5.52-9.15	0.45
Absent	45 47.87)	6.30±5.29	4.91-7.83	
History of hand washing before eating				
Present	44 (46.81)	5.30±4.11	4.23-6.42	0.07

Continued.

Child attributes	N (%)	Mean BLL ± SD (µg/dl)	95% CI	P value
Absent	50 (53.19)	8.02±6.29	6.47-10.06	
History of pets in house				
Present	30 (31.91)	6.53±4.38	4.98-7.85	0.61
Absent	64 (68.09)	6.80±5.99	5.65-8.34	
Use of colourful toys				
Present	52 (55.32)	7.29±5.63	5.77-8.75	0.24
Absent	42 (44.68)	6.07±5.34	4.67-7.90	
Use of kohl				
Present	79 (84.04)	7.19±5.64	6.13-8.43	0.05
Absent	15 (15.96)	4.20±3.99	2.42-6.43	
Use of folk/herbal medicine				
Present	52 (55.32)	7.86±5.93	6.32-9.55	0.03
Absent	42 (44.68)	5.24±4.55	3.83-6.62	

Table 3: Parental attributes and blood lead levels.

Parental factors	N (%)	Mean BLL ± SD (µg/dl)	95% CI	P value
Age of the mother (In years)				
<30	77 (81.9)	6.92±5.74	5.86-8.10	0.79
≥30	17 (18.1)	5.81±4.28	4.32-8.16	
Parity of mother				
< 2	30 (31.9)	5.80±4.86	4.05-7.93	0.28
≥ 2	64 (68.1)	7.15±5.77	5.91-8.46	
Maternal literacy				
Illiterate	28 (29.8)	8.55±6.35	6.37-11.39	0.12
Primary school	31 (33.0)	4.91±4.41	3.42-6.29	
High school	15 (15.9)	6.40±5.35	4.03-9.93	
Intermediate	13(13.8)	7.81±6.01	5.07-11.64	
Graduation	7 (7.4)	6.00±3.98	2.48-8.95	
Maternal frequent use of-kohl/surma				
Present	90 (95.7)	6.68±5.43	5.77-7.85	0.93
Absent	04 (4.3)	7.48±7.93	5.81-7.88	
Maternal frequent use of-sindoor				
Present	58 (61.7)	6.37±5.33	5.23-7.94	0.494
Absent	36 (38.3)	7.28±5.80	5.45-8.96	
Maternal frequent use of-lipstick				
Present	94 (100)	6.72±5.50	5.81-7.88	-
Absent	0	-	-	
Maternal frequent use of-dye				
Present	12 (12.8)	5.78±4.77	3.68-8.75	0.66
Absent	82 (87.2)	6.85±5.62	5.72-8.35	
Maternal anaemia				
Present	44 (46.8)	6.81±5.33	5.18-8.63	0.67
Absent	50 (53.2)	6.63±5.70	5.14-8.38	
Paternal smoking				
Yes	51 (54.3)	7.53±5.64	6.19-9.26	0.07
No	43 (45.7)	5.76±5.24	4.23-7.35	

BLL was considerably higher in children where kohl was regularly applied (7.19 versus 4.20 µg/dl, and p=0.05). Interestingly, use of folk/herbal medicinal remedies was found to be statistically significant risk factor for the EBLL (7.86 versus 5.24 µg/dl and p=0.030).

Parental attributes and blood lead levels

Maternal attributes and blood lead levels in respective subgroups are presented in Table 3. Maternal attributes of use of cosmetics such as kohl, sindoor, lipstick, dyes, age and parity were not found to be associated with higher blood lead level. Maternal age, parity, and maternal anemia were also not associated with higher blood lead levels (p>0.05, Table 3). Children with a history of paternal smoking had a higher blood lead level, however this was not significant statistically (7.53 vs 5.76, p=0.074, Table 3).

DISCUSSION

There is enough scientific evidence that blood lead levels (BLL) below 10 µg/dl are associated with adverse effects in children.[5-7] Consequently, in 2012, the centers for disease control and prevention (CDC) lowered the reference value of BLL to 5 µg/dl from 10 µg/dl. Applying the same cut-off limit, more than half (53%) of our study population of children with GDD had elevated BLL with a mean BLL of 6.72±5.50 µg/dl. Among the possible sources of lead exposure, regular application of kohl in the child's eyes and use of folk/ herbal medicine were identified as significant risk factors. Lack of regular hand washing habit and living in kaccha house also contributed to a higher serum lead level among the children. Other attributes such as pica, use of colourful toys, thumb sucking, and eating from roadside vendor did not show significant association with EBLL. None of the parental personal or socio-demographic factors were significantly associated with EBLLs. However, higher BLL was found among children whose fathers were smokers.

Although the mean blood lead level was higher than the cut off limit in our study population, we could not discern whether this was higher than the developmentally normal children with similar demographics due to the absence of a control group. Various other investigators have also found higher mean blood lead level in children with developmental delay as compared to normally developing children.[8,9]

In addition, other studies from the country involving normally developing children have also found high mean blood lead levels.[10-12] However, elevated BLL in more than half of children with developmental delay is a matter of concern and therefore it's environmental and demographic determinants need to be studied and modified accordingly. Lead wreaks its havoc so silently and insidiously that it often goes unrecognized and young children are at the greatest risk of suffering lifelong neurological, cognitive and physical damage. Lead irreversibly damages children's developing brains and the consequences can be devastating especially in developmentally delayed children.

The major sources of lead exposure identified by various investigators include lead paint, dust, soil, food and beverage, kajal, traditional folk remedies, old housing and parental occupational lead exposure.[13-15]

Use of kajal and traditional medicines were associated with elevated BLL in the present study. Potentially harmful levels of lead and other heavy metals were detected in Ayurvedic herbal medicine.[16] A higher level of BLL was also found in children living in kaccha house and having a father smoking at home. Similar finding was also observed in a study by Martínez-Hernanz.[17]

Blood leads levels for children in low- and middle-income countries continue to be dangerously high. Lead is a cumulative toxicant that affects multiple body systems and is particularly harmful to young children. There is no known safe level of lead exposure and relatively low levels of lead exposure that were previously considered 'safe' have been shown to damage children's health and impair their cognitive development. Childhood lead poisoning should command an urgent response. We recommend that future studies in children with developmental delay be carried out with a control group, and be directed at exploring putative environmental risk factors. Prevention of lead exposure, capacity building for BLL testing, public awareness and behaviour changes, policy making and legislation as well as regional and global action are highly desirable to curb this menace.

Limitations

Due to the impacts of the COVID-19 pandemic on delivery of health care services, the required sample size of 130 children could not be attained and a total 94 children and their mothers were studied instead. For the determination of child and parental attributes, mother's/guardian's response was relied upon which is subject to information bias including a recall bias.

CONCLUSION

A high BLL among children with developmental delay are a matter of serious concern. Use of folk/traditional medicines and application of kohl were identified as potential sources of exposure to lead. The high prevalence of EBLL in our study area might suggest exposure from environmental sources that need to be identified and desired modification for decreasing the exposure need to be executed. Addressing lead pollution and exposure among children will require a coordinated and multi-pronged approach.

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