Original Article

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Paediatrics Section

Prevalence of Elevated Blood Lead Levels and Factors Contributing to the Risk of Lead Poisoning among 1-5-year-old Children: A Cross-sectional Study

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ABSTRACT

Introduction: Lead is a well-documented potent environmental toxin that has various harmful effects on the body, growth, and development noticed since, birth. Despite notable advancements in the decrease of lead exposure, researchers found environmental, socioeconomic, and demographic factors associated with elevated blood lead levels in children in Chennai, India, aged 1-5 years. This underscores the necessity for additional research on correlated risk factors.

Aim: To assess the prevalence of elevated blood lead levels in children and estimate its values while identifying potential sources of lead exposure to the children.

Materials and Methods: The cross-sectional analytical research was conducted at SRM Medical College, Hospital, and Research Centre, Kattankulathur, Tamil Nadu, India, from July 2019 to July 2022. A total of 92 children aged 1-5 years attending the Paediatric Outpatient Department (OPD) and inpatients at the same hospital were included in the study. This study was conducted to examine the impact of lead exposure on children aged one to five years by using a lead exposure risk assessment questionnaire by World Health Organisation (WHO). Blood lead levels were measured using Lead Care II analyser equipment and lead care blood lead testing kits. Chi-square test and Fisher's exact test were applied to statistically analyse the data.

Results: The majority, 48 (52.17%), were boys, while 44 (47.83%) were girls. The study found that 8 (8.7%) out of all the children had lead toxicity. Thumb sucking was associated with higher lead toxicity, while frequent waste material combustion was linked to higher lead toxicity. Other risk factors like age, gender, residence conditions, recent renovations, and exposure to smoke or dust were not significantly associated with increased blood lead levels. Food prepared in metal vessels, water sources, canned food, traffic near home, imported food, cosmetics, home remedies usage, and parental education status were not significantly associated with increased blood lead levels.

Conclusion: Among the study population of 92 children, the prevalence of lead toxicity (>5 μg/dL) was found in 8 (8.7%) children. The results of present study point towards a significant association of lead toxicity in children with thumb sucking and combustion of waste material in surroundings. To fully understand lead exposure in primary and secondary care settings, greater sample sizes and additional research on confounding factors are required.

Keywords: Growth and development, Lead exposure, Lead toxicity, Thumb sucking, Waste material combustion

INTRODUCTION

Numerous organs and organ systems have been found to be harmed by lead, a potent environmental toxin. Lead poisoning has adverse effects from birth, including stunted physical and intellectual growth, lower productivity, behavioural problems, and poor scholastic performance [1]. In 2012, the Centers for Disease Control and Prevention (CDC) designated 5 μg/dL as the "blood lead reference value based on the 97.5th percentile of the population of children aged less than 5 years" (based on National Health and Nutrition Examination Survey (NHANES) data from 2007-2010) [2]. Normal lead levels for children aged 1-2 years are 0.86-1 μg/dL, and for children aged 3-5 years, they are 0.72-0.82 μg/dL [3].

Intellectual achievement at age 10 years is inversely correlated with blood lead (Pb) levels assessed at age 2 years [4]. On average, for each 1 μg/dL elevation in blood lead levels, the cognitive score is approximately 0.25-0.50 points lower, though the relationship is not linear across the blood lead level spectrum. Elevated blood lead levels have also been linked to learning disabilities, delayed language development, distractibility, and decreased executive functioning. It has been linked to various behavioural disorders, such as aggression, delinquency, and inattention [5].

Lead competes with and obstructs the metabolism of vital micronutrients such as iron, zinc, magnesium, and calcium, which are necessary for the production of haemoglobin, the proper operation of mitochondria, nerve cell transmission, and the activation of muscles [1]. Compared to adults, children are more susceptible to lead toxicity because of their immature central nervous systems and weak blood-brain barrier, which permits lead to enter the brain [6].

Indian children have been shown to be exposed to lead through cooking utensils containing lead, specific spices, and religious powders [7,8]. The use of tetra-ethyl lead combined with fuel in the late 20th century was the most significant historical source of lead exposure worldwide [9]. Children exposed to secondhand smoke with increased levels of lead dust and fumes were found to have higher blood lead levels [9]. India began to phase out leaded fuel from 1996 to 2000 [10]. Following the full implementation of the unleaded petrol policy, blood lead levels among Mumbai inhabitants were shown to have decreased by 60% between 1997 and 2002. Similarly, in the cities of Bengaluru, Amritsar, Mumbai, Chennai, and Lucknow, the phase-out of leaded petrol was associated with an average 33% decrease in blood lead levels [11].

Despite India's gradual phase-out of leaded gasoline, elevated blood lead levels persist in children, particularly in Chennai, a heavily industrialised city [12]. Urban children living in dilapidated homes constructed prior to the 1970s and those exposed to lead through industrial use-such as lead in water near mining operations or lead aerosolised from smelters or refineries-are most likely to have increased Blood Lead Levels (BLLs). Children who live in older houses, families with lower incomes than middle-class parents, and are more likely to suffer from lead poisoning than children who reside in rural areas [13]. The differences in the geometric mean of BLLs persist even when accounting for income and ethnicity [14]. Due to rapidly changing demography, previously thought of risk factors may not persist; therefore, more studies are needed to explore the relationship between current sources of lead exposure in children aged 1 to 5 years in Chennai and various social, demographic, and environmental factors, despite significant advancements in lead reduction.

Hence, the present study was conducted to evaluate the prevalence of elevated blood lead levels in children and estimate its values while identifying potential sources of lead exposure to the child.

MATERIALS AND METHODS

The present cross-sectional analytical research was done in the Department of Paediatrics at SRM Medical College, Hospital, and Research Centre, Kattankulathur, Chennai, Tamil Nadu, India, for a period of three years, from July 2019 to July 2022. Institutional Ethical Committee approval was obtained before the study commenced (IEC no: 1751/IEC/2019).

Inclusion criteria: Children aged between 1 and 5 years attending the Paediatric OPD and those admitted to the ward (for various reasons not related to lead poisoning) were included in the study as a part of surveillance after their parents/guardians provided informed written consent.

Exclusion criteria: Children whose parents/guardians denied participation and those children who were receiving treatment for lead poisoning were excluded from present study.

Sample size calculation: With a prevalence of 37% from the previous study [15], and an absolute precision of 10%, the sample size was calculated based on the following formula.

$$\text{Sample Size} = \frac{4 \times P \times Q}{d^2}$$

Prevalence, P=37

Q=100-P=63

Allowable Error, d=10

The sample size according to this formula is 94. Each lead care testing kit can analyse of 46 samples and two controls. As two kits were planned to be used for operational convenience, the sample size taken was 92.

Study Procedure

The lead exposure risk assessment questionnaire comprised 30 questions adopted from the CDC questionnaire [16-18] and modified for the Indian population after extensive discussions with a panel of experts in the fields of research and paediatrics. The questionnaire was further developed by conducting four focus group discussions involving 30 caregivers/parents of randomly selected children aged less than five years. These questions were further modified to make them more relevant and easily comprehensible to the testing population. The questionnaire was pretested among 10 randomly selected children and their caregivers/parents who were not on treatment or known cases of lead poisoning. It was later modified for context and clarity. A consent form was developed and attached to the questionnaire, which was distributed among the study population. The questionnaire was prepared in English and then translated into Tamil. The reliability and validity of the questionnaire were tested by test-retest studies and back translation for the Tamil questionnaire. After analysis by a panel of experts using the Likert scale, the validity index was calculated to be 0.8 for present study. For reliability, subjects from the target population participated in the test-retest studies. The agreement between answers was measured through the intraclass correlation coefficient, which was found to be 0.7 for present study.

The Lead Care II analyser equipment (ESA Biosciences Inc., Chelmsford, MA) and the Lead Care blood lead testing kits (ESA, Inc., USA) were used to measure the blood lead levels of all study participants. As the test is conducted by finger pricking, a laboratory technologist was not needed to perform it. A blood lead level of more than 5 µg/dL was considered significant, implying lead toxicity.

STATISTICAL ANALYSIS

The mean, median, mode, and standard deviation were used to express numerical variables such as age and lead levels. Categorical variables like gender and components of the lead exposure risk assessment questionnaire are represented in frequencies and percentages. The odd's ratio with confidence intervals is used to illustrate the risk of elevated lead levels. Significance tests are conducted using the Chi-square test. When more than 20% of the cell values have an anticipated cell value of less than 5, Fisher's-exact test is applied. A p-value less than 0.05 is considered statistically significant. The data were entered into an MS Excel sheet and analysed using Statistical Packages for Social Sciences (SPSS) software version 16.

RESULTS

The study population comprised 92 children (aged 1-5 years) attending the paediatric OPD and those admitted as inpatients in the Department of Paediatrics at SRM Medical College, Hospital, and Research Centre in Kattankulathur, Chennai. There were 48 boys (52.17%) and 44 girls (47.83%). In the present study, the majority of children were aged three years and more-62 children (67.39%). Out of the 92 children included in present study, 84 children (91.3%) were found to have lead levels below 5 µg/dL [Table/Fig-1].

Parameters	Frequency (n)	Percentage (%)
Age (years)		
1	14	15.22
2	16	17.39
3	22	23.91
4	20	21.74
5	20	21.74
Gender		
Female	44	47.83
Male	48	52.17
Lead toxicity		
Yes	8	8.70
No	84	91.30
Total	92	100.00

[Table/Fig-1]: Distribution of age, gender and lead toxicity among the study population.

Among the study population with lead level distribution, 70 children (76.09%) had low lead levels, followed by 14 children (15.16%) with high blood lead levels. The prevalence of lead toxicity (>5 µg/dL) was found in 8 (8.7%) children [Table/Fig-2].

A significant association was noted in children who sucked their thumbs, where 6 (24%) with thumb sucking had lead toxicity, which was higher compared to those without thumb sucking, of whom 2 (2.98%) had lead toxicity [Table/Fig-3]. The difference was statistically significant ($p<0.05$). Odd's ratio (95% CI)=10.26 (1.91-55.07).

An association was also observed between the combustion of waste materials in the surroundings and increased blood lead levels

Lead level (µg)	Frequency (n)	Percentage (%)
Low (<2)	70	76.09
2-3	8	8.69
3-4	4	4.3
4-5	2	2.17
>5 (Toxicity level)	8	8.69
Total	92	100.00

[Table/Fig-2]: Distribution of lead levels in blood among the study population.

Risk factors	Response	Lead toxicity		Odd's ratio	p-value
		Yes	No		
Condition of residence	Bad	2 (10.52%)	17 (89.47%)	1.31 (0.24-7.1)	0.313
	Good	6 (8.21%)	67 (91.78%)		
Recent renovation of home	Yes	2 (7.69%)	24 (92.3%)	0.83 (0.16-4.42)	0.318
	No	6 (9.09%)	60 (90.4%)		
New windows at home	Yes	2 (7.69%)	24 (92.3%)	0.83 (0.16-4.42)	0.318
	No	6 (9.09%)	60 (90.4%)		
Peeling of paint in woodwork, toy, furniture andbuilding wall	Yes	4 (9.52%)	38 (90.47%)	1.21 (0.28-5.17)	0.277
	No	4 (8%)	46 (92%)		
Thumb sucking	Yes	6 (24%)	19 (76%)	10.26 (1.91-55.07	0.005
	No	2 (2.98%)	65 (97.01%)		
Food prepared in metalvessels	Yes	5 (10.41%)	43 (89.58%)	1.59 (0.36-7.08)	0.244
	No	3 (6.81%)	41 (93.1%)		
Educational status of parent	School	7 (12.06%)	51 (87.9%)	4.53 (0.53-38.52)	0.11
	Graduate	1 (2.94%)	33 (97%)		

[Table/Fig-3]: Descriptive indoor characteristics of study population and their association with blood lead levels.

in children, which was found to be significant. Out of the 92 children, 5 subjects (18.51%) with frequent waste material combustion in the vicinity had lead toxicity, which was higher compared to those without waste material combustion, of whom three children (4.61%) had lead toxicity [Table/Fig-4]. The difference was statistically significant (p<0.05). Odd's ratio (95% CI)=4.7 (1.04-21.3).

Multiple regression analysis revealed that thumb sucking and waste material combustion were significantly associated with lead poisoning in children [Table/Fig-5].

Risk factors	Response	Lead toxicity		Odd's ratio	p-value
		Yes	No		
Outdoor play area- bare soil	Yes	6 (8.82%)	62 (91.17%)	1.06 (0.2-5.67)	0.325
	No	2 (8.33%)	22 (91.66%)		
Smoke or dust coming from external sources	Yes	4 (14.28%)	24 (85.71%)	2.5 (0.58-10.81)	0.14
	No	4 (6.25%)	60 (93.75%)		
Waste material as combustible	Yes	5 (18.51%)	22 (81.4%)	4.7 (1.04-21.3)	0.038
	No	3 (4.61%)	62 (95.3%)		
Source of water	Piped	7 (10.29%)	61 (89.7%)	2.64 (0.31-22.65)	0.25
	Underground	1 (4.16%)	23 (95.8%)		
Intake of canned food	Yes	4 (7.69%)	48 (92.3%)	0.75 (0.18-3.2)	0.266
	No	4 (10%)	36 (90%)		
Traffic near home	Heavy	4 (14.28%)	24 (85.7%)	2.5 (0.58-10.81)	0.14
	Less	4 (6.25%)	60 (93.7%)		
Imported food and cosmetics, home remedies usage	Yes	6 (13.63%)	38 (86.3%)	3.63 (0.69-19.04)	0.086
	No	2 (4.16%)	46 (95.8%)		

[Table/Fig-4]: Descriptive outdoor characteristics of study population and their association with blood lead levels.

Parameters	B	SE	Wald	df	p-value	Adj. odd's ratio	95% CI for Adj. Odd's	
							Lower	Upper
Thumb sucking	3.144	1.043	9.082	1	0.003	23.201	3.002	179.297
Waste material as combustible	2.522	0.996	6.413	1	0.011	12.448	1.768	87.631
Constant	-5.002	1.111	20.253	1	<0.001	0.007		

[Table/Fig-5]: Logistic regression analysis for predicting lead toxicity among children.
Only risk factors with significant associations are represented here for simplicity. Other risk factors were not found to be significant

Other risk factors that were analysed, such as age, gender, condition of residence, recent renovation of the house, new windows, previous land use before constructed, outdoor play area with bare soil, peeling paint in woodwork, and smoke or dust from an external source, were not significantly associated with increased blood lead levels.

Factors like food prepared in metal vessels, water source, canned food usage, proximity to traffic, imported food, cosmetics, home remedies usage, parents' educational status, years of house construction, and duration of residence were also not significantly associated with increased blood lead levels, as assessed by the correlation between the questionnaire and blood lead levels among the study population.

DISCUSSION

Despite the elimination of leaded petrol, the problem of lead poisoning still exists in India. This is largely due to children's early and increasing hand-to-mouth activity, and fast expanding brains, making them the most vulnerable group to lead poisoning. The US Centers for Disease Control (CDC) has gradually decreased the standards for Blood Lead Levels (BLL) in children. For this analysis, a blood lead level ≥5 µg/dL is defined as a higher blood lead levels [19].

The main objective of present study is to estimate blood lead levels in children and identify possible sources of lead exposure in children. The strengths of present study comprise of a standard, reproducible data collection methods. In present study population, 8 children (8.7%) had lead toxicity (>5 ug/dL). The study results show a comparatively low mean levels of BLL and a lower proportion of children with BLL greater than 5 µg/dL. The study observed an average BLL of 0.93 mcg/dL (95% confidence interval: 0.564-1.296).

Palaniappan K et al., studied the lead exposure and visual-motor abilities in children aged 3-7 years from Chennai, India. In their cross-sectional study among 814 school children, they observed that the average blood lead level was 11.4±5.3 µg/dL [20]. The values obtained in present study were lower compared to the studies for the meta-analysis of blood lead levels in India by Ericson B et al., in 2018. The pooled arithmetic mean of blood lead levels from those studies was 6.86 µg/dL (95% Confidence Interval: 4.38-9.35). Children less than two years of age had an average blood lead level of 8.49 µg/dL, and those children under seven years of age had an average blood lead level of 6.9 µg/dL. In their 17 studies, only one was from a rural area, where the mean blood lead level was 5.9 µg/dL, compared to the mean blood lead level from sixteen urban studies as 6.92 µg/dL [21].

Regarding the association of risk factors with increased BLL, this study suggests that thumb sucking and exposure to combustion of waste material are important risk factors with a positive correlation. The present study could not find significant associations with other risk factors like food prepared in metal vessels, the source of water, usage of canned food, traffic near home, imported food, cosmetics, home remedies usage, age, gender, condition of residence, recent renovation of the house, new windows, previous use of land before the building was constructed, outdoor play area with bare soil, peeling of paint in woodwork, smoke or dust coming from an external source, educational status of the parents, years of construction of their house, and duration of stay in residence. Roy A et al., concluded from their study that lead exposure and reduced haemoglobin levels are related to deficits in the intelligent quotient level [22]. In 2006, Jain NB et al., discovered a correlation between elevated blood lead levels in children under three years old and rising age, a lower standard of living index, more than 95 weight/height percentile, and a higher total number of children ever born to a mother [23]. In 1998, Bruce P et al., found that a number of factors, including living in a city, being Black, having a lower property value, owning a home built before 1950, having a higher population density, having a higher percentage of people living in poverty, having fewer high school graduates, and having fewer owner-occupied homes, were linked to a higher risk of elevated blood lead levels in children [24].

After adjusting for age and gender, the primary caregiver's educational level, the children's water collecting techniques, the home's varnishing, and the family members' occupational recycling of metals other than lead were among the factors used by Albalak R et al., to predict the log in Jakarta, Indonesia. Blood lead levels were measured and linked to childhood lead poisoning [25]. Ying X-L et al., investigated the causes of lead poisoning in children in China. According to their research, traditional medicines and industrial pollution are significant sources of lead exposure. Other non industrial forms of lead exposure included tin pots and tinfoil that contained lead. In their investigation, household lead paint was noted as an uncommon source of lead [26]. Brown LM et al., discovered a correlation between children's blood lead levels and those of their carers, indicating a shared environmental exposure. Children and their caregivers may be exposed to lead by melting batteries used to make fishing sinkers, which is an avoidable risk [27]. A comparison of the findings in the present study with contrast studies is presented in [Table/Fig-6] [20-27].

Authors name	Place/year of the study	Sample size	Factors significantly Associated	Prevalence of lead poisoning
Bruce P et al., [24]	Monroe County, New York 1994-1995	20,296 children (<six-year-old)	Black race, lower housing value, housing built before 1950, higher population density, higher rates of poverty, lower percent of high school graduates lower rates of owner-occupied housing.	Lead toxicity for this study was considered 10 µg/dL and more. Of the 20296 children: 5531 (27%) had a blood lead level of 10 mg/dL or higher, 1042 (5%) had a blood lead of 20 mg/dL or higher, 81 (0.4%) had a blood lead level of 40 mg/dL or higher.
Roy A et al., [22]	Chennai, India. 2013	708 children in Chennai aged 3-7 years	Reduced haemoglobin levels are related with deficits in Intelligent Quotient level.	Average blood lead level in their population was 2.9-5.5µg/dL.
Jain N et al., [23]	Mumbai and Delhi, India. 2006	1081 children aged <3 years	Increasing age, a lower standard of living index, greater than 95 weight/height percentile, and higher total number of children ever born to mother.	Retrospective study 568 children having lead levels <10 µg/dL 510 (48.2%) children having levels >10 µg/dL. Lead toxicity for this study was considered to be 10 µg/dL.
Palaniappan K et al., [20]	Chennai, India 2003-2006	814 children aged 3-7 years	An increase of 10 µg/dL was associated with a decrease of 2.9 points in the Drawing subtest and of 2.6 points in the visual motor composite score and a decrease.	Mean blood lead level in this population was 11.4±5.3 µg/dL. Half (52.5%) of the children having a level >10 mg/dL
Ericson B et al., [21]	India Studies from 2010-2018 included.	31 studies representing the BLLs of 5472 people in 9 states	Metanalysis of blood lead levels in India and the attributable burden of disease Lead-attributable DALYs are likely underestimated in children particularly with regard to associated intellectual disability outcomes in children.	Metanalysis of studies regarding blood lead levels in India revealed arithmetic mean of BLL in paediatric population to be (<18 years) 6.86 µg/ dL (range 4.38-9.35). This BLL would result in an average decrement of 4 IQ points (95% CI: 2.5-4.7) for children under age 10.
Albalak R et al., [25]	Jakarta, Indonesia 2003	397 children (<18 years)	Blood lead levels and risk factors for lead poisoning among children Population based cross section cluster survey where 397 children aged 6-12 years were assessed Significant association noted in children living near highways/major intersections, water collection methods. BLLs in children in this study were moderately high and consistent with BLLs of children in other countries where leaded gasoline is used.	Geometric mean BLL of the children was 8.6 mg/dL (range: 2.6-24.1 mgydL). 35% of children had BLLs >10 mg/dL 2.4% had BLLs >20 mg/dL. Approximately one-fourth of children had BLLs 10-14.9 mg/dL. Lead toxicity was considered to be BLL>10 mg/dL.
Ying X-L et al., [26]	Shanghai, China 2011-2016	515 children	Sources, symptoms and characteristics of childhood lead poisoning: experience from a lead specialty clinic 222 children (43.1%) were exposed to industrial lead pollution whereas 41.4% (213 cases) were induced by folk medicines used widely throughout China. Non industrial sources of lead exposure-tins pots and tin foil. Rare source- household lead paint	Their BLLs ranged from 5 to 126 µg/dL. The geometric mean and median BLLs were 24 and 26 µg/dL, respectively. Lead toxicity was considered to be BLL >10mg/dl. 11.6% had BLLs >45 µg/dL constituting severe lead poisoning. 8.5% patients had BLLs <10µg/dL
Brown LM et al., [27]	Chuuk State, Micronesia 2005	256 children aged 2-6 years 241 care givers	Blood lead levels and risk factors for lead poisoning in children and caregivers Cross-sectional survey from 20 randomly selected villages was done. Significant association noticed in: - Children living on an outer island - Children with caregiver having elevated BLL - Children having a family member who made lead fishing weights	Children's geometric mean BLL was 40 mg/L, ranging from 1 to 370 mg/L, and the prevalence of elevated BLLs was 20%. BLLs were higher in boys (47 mg/L) than girls (33 mg/L). An elevated BLL in this study was defined as higher than or equal to 100 mg/L.
Present study	SRM Medical College, Hospital and Research Centre, Kattankulathur, Tamil Nadu, India 2019-2022	92	Thumb Sucking, combustion of waste material.	Lead toxicity observed in 8 (8.7%) of 92 children (5 µg/dL and more).

[Table/Fig-6]: Summary of related articles and their conclusions with lead levels [20-27].
DALYs: Disability adjusted life years

However, in the present investigation, authors did not detect an association between occupations or other parental variables determining the blood lead levels among the children, as also stated by other investigators.

Limitation(s)

Although the sample size of present study was enough to assess the proportion or prevalence of children with >5 μg/dL, it was too small for applying statistical tests of association. Hence, the role of confounders could not be explored since, adjusted analysis cannot be done with the given sample size and lower prevalence. The study was conducted in a hospital-based tertiary care setting, where the study population is not representative of the general population.

CONCLUSION(S)

Among the study population, 14 children (15.16%) were found to have high blood lead levels, and the prevalence of lead toxicity (>5 μg/dL) was found in 8 (8.7%) children. The results of present study point towards a significant association between lead toxicity in children and thumb sucking and the combustion of waste materials in their surroundings. A community-based study is preferred for a better understanding of the true problem. Health education on lead levels and prevention, particularly thumb sucking and waste combustion, is crucial. The findings of present study will help identify persistent health hazards linked to lead exposure in homes, even after legislation has been enacted. The hope is to develop more effective lead-abatement methods. Further, studies with larger sample sizes and consideration of confounding factors in primary and secondary care settings are needed to fully comprehend the issue.

REFERENCES

[1] Gidlow DA. Lead toxicity. Occup Med (Lond). 2015;65(5):348-56.
[2] Markowitz M. Lead poisoning: An update. Paediatr Rev. 2021;42(6):302-15.
[3] Ruckart PZ, Jones RL, Courtney JG, LeBlanc TT, Jackson W, Karwowski MP, et al. Update of the blood lead reference value-United States, 2021. Morb Mortal Wkly Rep. 2021;70(43):1509-12.
[4] Bellinger DC, Stiles KM, Needleman HL. Low-level lead exposure, intelligence and academic achievement: A long-term follow-up study. Paediatrics. 1992;90(6):855-61.
[5] Dietrich KN, Ris MD, Succop PA, Berger OG, Bornschein RL. Early exposure to lead and juvenile delinquency. Neurotoxicol Teratol. 2001;23(6):511-18.
[6] Marchetti C. Molecular targets of lead in brain neurotoxicity. Neurotox Res. 2003;5(3):221-36.
[7] Lin CG, Schaider LA, Brabander DJ, Woolf AD. Paediatric lead exposure from imported Indian spices and cultural powders. Paediatrics. 2010;125(4):e828-35.
[8] Rolston DD. Uncommon sources and some unsual manifestations of lead poisoning in a tropical developing country. Trop Med Health. 2011;39(4):127-32.
[9] Brown MJ, Patel P, Nash E, Dikid T, Blanton C, Forsyth JE, et al. Prevalence of elevated blood lead levels and risk factors among children living in Patna, Bihar, India 2020. PLOS Glob Public Health. 2022;2(10):e0000743.
[10] Singh AK, Singh M. Lead decline in the Indian environment resulting from the petrol-lead phase-out programme. Sci Total Environ. 2006;368(2-3):686-94.
[11] Nichani V, Li WI, Smith MA, Noonan G, Kulkarni M, Kodavor M, et al. Blood lead levels in children after phase-out of leaded gasoline in Bombay, India. Sci Total Environ. 2006;363(1-3):95-106.
[12] Chatham-Stephens K, Caravanos J, Ericson B, Sunga-Amparo J, Susilorini B, Sharma P, et al. Burden of disease from toxic waste sites in India, Indonesia, and the Philippines in 2010. Environ Health Perspect. 2013;121(7):791-96.
[13] Egan KB, Cornwell CR, Courtney JG, Ettinger AS. Blood lead levels in U.S. children ages 1-11 years, 1976-2016. Environ Health Perspect. 2021;129(3):037003.
[14] Centers for Disease Control and Prevention. Blood lead levels in children aged 1-5 years- United States, 1999-2010. 2023;62(13);245-248. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6213a3.htm.
[15] Dalton MA, Sargent JD, Stukel TA. Utility of a risk assessment questionnaire in identifying children with lead exposure. Arch Paediatr Adolesc Med. 1996;150(2):197-202.
[16] Ossiander EM. A systematic review of screening questionnaires for childhood lead poisoning. J Public Health Manag Pract. 2013;19(1):E21-29.
[17] Muñiz MA, Dundas R, Mahoney MC. Evaluation of a childhood lead questionnaire in predicting elevated blood lead levels in a rural community. J Rural Health. 2003;19(1):15-19.
[18] Centers for Disease Control and Prevention. Screening young children for lead poisoning: Guidance for state and local public health officials. ERIC Clearinghouse; 1997. Available from: https://stacks.cdc.gov/view/cdc/147831.
[19] Cory-Slechta DA. Low level lead exposure harms children: A renewed call for primary prevention. 2012.
[20] Palaniappan K, Roy A, Balakrishnan K, Gopalakrishnan L, Mukherjee B, Hu H, et al. Lead exposure and visual-motor abilities in children from Chennai, India. Neurotoxicology. 2011;32(4):465-70.
[21] Ericson B, Dowling R, Dey S, Caravanos J, Mishra N, Fisher S, et al. A meta-analysis of blood lead levels in India and the attributable burden of disease. Environ Int. 2018;121(Pt 1):461-70.
[22] Roy A, Ettinger AS, Hu H, Bellinger D, Schwartz J, Modali R, et al. Effect modification by transferrin C2 polymorphism on lead exposure, hemoglobin levels, and IQ. Neurotoxicology. 2013;38:17-22.
[23] Jain NB, Hu H. Childhood correlates of blood lead levels in Mumbai and Delhi. Environ Health Perspect. 2006;114(3):466-70.
[24] Lanphear BP, Byrd RS, Auinger P, Schaffer SJ. Community characteristics associated with elevated blood lead levels in children. Paediatrics. 1998;101(2):264-71.
[25] Albalak R, Noonan G, Buchanan S, Flanders WD, Gotway-Crawford C, Kim D, et al. Blood lead levels and risk factors for lead poisoning among children in Jakarta, Indonesia. Sci Total Environ. 2003;301(1-3):75-85.
[26] Ying XL, Gao ZY, Yan J, Zhang M, Wang J, Xu J, et al. Sources, symptoms and characteristics of childhood lead poisoning: Experience from a lead specialty clinic in China. Clin Toxicol (Phila). 2018;56(6):397-403.
[27] Brown LM, Kim D, Yomai A, Meyer PA, Noonan GP, Huff D, et al. Blood lead levels and risk factors for lead poisoning in children and caregivers in Chuuk State, Micronesia. Int J Hyg Environ Health. 2005;208(4):231-36.

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