Original Research Article

Study on blood lead levels in children

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Abstract

Background: Recent evidence incidence that low level of lead exposure, previously thought to be safe, have adverse effects on neurobehavioural and cognitive development of the child.
Aim: This study was a clinical study composed of children who were likely to be at higher risk for lead exposure. To correlate Blood lead levels with the clinical profile, developmental and behavioral profile and bio-chemical parameters of these children.
Materials and methods: Patients attending Niloufer hospital, Hyderabad were evaluated for pica were considered to be at risk for inorganic lead poisoning and Children who working at petrol bunks were at risk of Organic Lead poisoning Results: Children of lower socio-economic state of classes of 3 and 4 and those living poor housing conditions are associated with high blood lead levels than children of higher and those in good housing conditions. Pica children had significantly higher blood levels, more behaviour problems and lower hemoglobin levels than controls. Pica particularly for multiple (mud, plaster, coal) and duration of habit for more than 6 months are associated with high blood lead levels. Children working in petrol bunks for more than 1 year showed a high Blood Pb levels and low hemoglobin levels than those working for less than 1 year and controls. Children of petrol bunk group, showed more behavioural problem and significant organic impairment and low intelligence than controls. Children of petrol bunk group, similar to pica group showed a high Blood Lead levels.
Conclusion: Present study suggests that oral ingestion in an important route of inorganic poisoning in children with pica, where inhalation through respiratory passages and absorption through intact skin is an important route of organic lead poisoning in children working in petrol bunks or automobile garages-by virtue of their occupation.

Key words

Study, Blood, Lead, Children.

Introduction

Environmental population and its effect on human health is a major global concern in recent years. Among the pollutants, heavy metals like lead, mercury, cadmium and arsenic constitute the main important toxic substance because of

- Their potential adverse effects on various systems of the human body and
- Their ubiquitous distribution.

Lead has been an important metal in human societies over many thousands of years. Its low melting point, durability and easy availability accounted for its early use. The use of lead has increased dramatically since the early days of the industrial revolution. Man has increased atmospheric lead a thousand fold by industrialization. In the 17th century, the production of lead was under 0.4 million tones/years. Over the last 200 years production has increased to more than 3.5 million tons/year, with an increase in the rate of atmospheric lead at 5% each year. Interestingly, since the 1970's a downward trend in atmospheric lead and a concomitant decline in median blood lead level among children was observed in Chicago. This is attributed primarily to the use of lead-free petrol and also to the strict regulations on indiscriminate use of lead in industrial and domestic life [1].

In contrast with the developed countries, in India, lead production and consumption is increasing day by day with urbanization. The exponential rise in the use of automobiles, non-availability of unleaded petrol, lack of regulations on use of lead on industries, and the absence of any checks over the safe disposal of lead from industrial effluents have resulted in high environmental contamination. Because of scarcity of data regarding the severity and prevalence of lead toxicity in children, lack of awareness of the seriousness of lead pollution both to the public and to the Indian government, the future trend remains uncertain. Recently India announced the introduction lead free petrol by 1997 initially in four major cities (Delhi, Bombay, Chennai, and Calcutta) and subsequently to other parts. One of the automobile manufacturers will be introducing, by the end of 1995 lead converters, in place of old silencers which absorb lead from engine exhausts and help in reducing atmospheric pollution. This is certainly a beginning of prevention of lead pollution in India, but we still have a long way to go [1, 2].

Since the advent of effective industrial hygiene and safety methods, the occurrence of lead poisoning in adults has declined while the occurrence of childhood lead poisoning has reached epidemic proportions. Now, it is essentially a disease of childhood. The past decade has seen a change in the clinical picture of childhood lead poisoning from a high frequency of symptomatic, potentially lethal cases to a high frequency of asymptomatic, undetected cases. It has been realized that the asymptomatic or "sub-clinical" disease among children may in the long run, represent an even greater threat due to its insidious nature [3].

Recent evidence incidence that low level of lead exposure, previously thought to be safe, have adverse effects on neuro behavioural and cognitive development of the child. The emphasis has shifted from recognition of symptoms to detection by screening techniques and environmental has from recognition of symptoms to detection by screening techniques and environmental modifications. Following thorough review of available research data on childhood lead toxicity, the center for disease control and prevention (CDC) has lowered the blood lead levels above which children are considered risk for lead toxicity - from 40 ug/dl in 1988 to 10 ug/dl in 1991 [4]. Universal blood lead screening for all children below 1 year and preferably all children below 2 year has been recommended. We studied blood lead levels in children exposed to potentially high levels of organic and inorganic lead and blood lead levels with the clinical profile and developmental and behavioural profile.

Materials and methods

This study was a clinical study composed of children who were likely to be at higher risk for lead exposure. All children who attended the Child Guidance Clinic of Niloufer Hospital were evaluated for pica was considered to be at risk for inorganic lead poisoning. The group of older children who worked at petrol bunks of Hyderabad city and were likely to be at higher risk for organic lead poisoning. Written informed consent was taken from parents of all participants.

Study was divided in 4 groups with the subjects available as

Group - 1: Children with no history of pica or other exposure to lead having a similar socio-economic and family background as controls.

Group - 2: Pica with Mental retardation

Group - 3: Children screened by positive history of pica.

Group - 4: Children working in petrol bunks of age >14 years

As blood lead level estimation is an expensive and time consuming process, the number of controls was limited to 6 in the pica group and 11 in the petrol bunk group. Parameter studied were comprehensive evaluation of the history clinical status. Developmental and behavioural and the laboratory evaluation of the children were completed. Separate Performa were used for each of these areas.

Clinical: Data regarding age, sex, history of type of pica, occupation and duration of work, socio-economic status and education were collected. A detailed history of symptoms especially pertaining to lead toxicity and nutritional deficiencies were also taken. Anthropometric data was collected and a thorough general and systemic examination was done specifically looking for signs of lead toxicity and nutritional deficiencies.

Developmental and behavioural profile: Detailed history regarding developmental delay, mental retardation, behavioural and scholastic problems was collected from the families as well as from the hospital records. At the field level, the ‘Benders Gestalt Cards’ were used for assessing organicity. ‘The Ravens Coloured Progressive Matrices’ for children below 12 year and the ‘Standard Ravens Matrices’ for children above 12 year were used for assessing intelligence. In group - 2, only 12 out of 22 children were assessed as they were employees working in different shifts. Nevertheless as they are under follow up, a detailed psychological testing will be completed including the ‘Weschlers Intelligence Test’.

Biochemical: With the consent of the parents and older children, with all sterile precautions, using disposable syringes, 3 ml of blood was drawn from the antecubital vein into a heparinized test tube and sealed immediately with an air tight paraffin film. All the collected samples were submitted to the National Institute of Nutrition, Hyderabad in an ice filled container maintaining the cold chain for initial processing. Estimation of dALAD activity and whole blood lead levels were conducted as described below. Simultaneously blood was drawn for complete blood picture.

Hemoglobin estimation: It was done with Sahli’s hemoglobin meter.

Peripheral smear: The smear was prepared and immediately stained with Leishman’s stain all slides were studied for the type of anemia, basophilic stippling and for any abnormal cells.

Estimation of lead levels in whole blood done by graphite based atomic absorption spectrometry by using Special equipment a ‘Varian Techron model AA6 Graphite furnace atomic absorption spectrophotometer.

Where ever necessary statistical analysis was done using one way analysis of variance and the modified student 't'-test.

Definitions used in the study

Pica: The habit of repeated or chronic ingestion of 'non – nutrient' substances. (Which may include plaster, charcoal, clay, wool, ashes, paints, and earth) this excludes not tasting or mouthing of objects in any child above 18 months.

Socio-economic status:

Class-1	Big business Professional Govt. employees, class 1,2 and 3
Calss-2	Govt. employees, class 4 Permanent employees in a private sector
Class-3	Petty business Self employed
Class-4	Daily wages Hand to mouth subsistence
Class-5	Others

Housing conditions:

Flooring	Pakka (covered with/tiles without or any gap) Kutcha (and thing other than this)
Roof	Pakka (made up of RCC roof) or Kutcha (anything other than this)
Walls	Pakka (bricks/stone wall well-constructed with cement plaster) or Kutcha (anything covered with mud clay, paint with feedings)

Results

The study results were statistically analyzed using the ANOVA (one way analysis of variance) and compared in 4 groups. Every child with a positive history was included in the study 39 such children were selected for study of inorganic lead poisoning. Siblings of the study group with no history of pica or other exposure to lead were taken as controls. 22 children, working in petrol bunks of Hyderabad city for more than a period of 3 months, were requested to participate in the study of organic lead poisoning.

Group - 1 (Controls): Out of the 6 were the siblings of pica group, with a mean age of 6.6 year (range -3-11 year) and 11 children were from school health clinic of Niloufer hospital had mean age of 12.3 years (range 8-14 year).

Group - 2 (Pica with MR): Out of the 39 children with pica, 7 were found to be mentally retarded with a mean age of 3.8 years (range2-7 years) in all these cases a delay development was noted by parents prior to the onset of pica. (Among them two suffered birth asphyxia, one had neonatal jaundice, one had encephalitis and one child was born to PIH mother and in remaining two children no cause for retardation was identifiable.)

Group-3 (Pica alone): Out of 39, 32 children with no mental retardation had mean age of 4.6 year

Group-4 (Children working in Petrol Bunks): 22 children were agreed for the study, all were working for more than 3 months. 4 children (out of 22) were working for less than 1 year had a mean age of 13 year, and remaining 18 children were working for more than 1 year had a mean age (range 10-15 years) as per **Table - 1**.

Hematological parameters: Group - 2 showed lowed hemoglobin of 8.5% (+1.2) followed by group 3 with Hb% of 10.5 gm/dl (+1.8) and group 4 with mean Hb% of 10.9 (+1.3) whereas controls showed a mean hemoglobin of 13 gm/dl (+0.7). The difference between control (group 1) and other study groups (2, 3 and 4) were statistically significant with a P valve of e <0.00l (**Table – 2**).

85% of group II, 40 % of group-III, 23% of group-IV and none from group – I had hemoglobin of less than 10 gm/dl. 18 children (out of 39)of group II and III, 12 children of group IV showed hematological changes of lead toxicity like microcytic hypochromic anemia, anisocytosis, few target cells and crenated RBC. Three of pica children and 2 of petrol bunk children showed definite signs of lead toxicity like basophilc stippling.

Table - 1: Clinical and laboratory results of study.

Group and number	Age in year mean (range)	Hb g/dl mean+_SD	Blood lead ug/dl (p-value)
Group-1 (N=17)	12.3 year (8-14 year)	13 ± 0.7	23±1.1
Group-2 (N=7)	3.8 year (2-7 year)	8.5±1.2	36.93±5.26 (<0.001)
Group-3 (N=32)	4-6 year (2-10 year)	10.5±1.8	30.6±8.16 (<0.001)
Group-4 (N=22)	13.3 (10-15 year)	10.9±1.3	35.86±7.02 (<0.001)

Table - 2: Hemoglobin in groups.

Group and number	Group (number)	<9.9 Hb gm%	10-10.9 Hb gm%	11-11.9 Hb gm%	12-12.9 Hb gm%	>13 Hb gm%
Group - 1 (N=17)	Controls, 17	0	0	2	7	8
Group – 2 (N=7)	Pica with MR, 7	6	1	0	0	0
Group – 3 (N=32)	Pica, 32	13	6	2	8	1
Group – 4 (N=22)	Petrol bunk (group-2) Workers 22	5	5	5	6	1

Blood Lead Levels: Mentally retarded children with pica (group-2) showed a higher mean BPB level of 37 ug/dl (+5.26 SD) and children with pica alone (group-3) for > 1 year duration showed a Blood Pb of 39 ug/dl (1 3.7), whereas those who are working for less than 1 year showed Blood Pb of 23.1 (+0.41) 17 of the controls (group-4) with similar socio-economic background showed Blood Pb of 24 (+1.1). The difference between the study of groups (group 1, 2 and 3) and controls were statistically significant with a 'P' value of <0.001. 85% children of group of group 2; 47% children of group 3, 81% of children of group 4 and only one child from controls had BPb level of >29 ug/dl. Similarly 2 of mental retarded children, 3 of the group3, 5 (22%) of group 4 children and none of the controls showed Blood Pb of >40 ug/dl (**Table – 3**).

According to CDC 1991 any level above 40 ug/dl is the definite indication of chelation therapy whether symptomatic or not.

Socio – economic status - 70% of study group 2and 3 belongs to the lower socio-economic status of class 3and4 and remaining 30% to the socio-economic status of class 1 and2. All children of group 4 (children of petrol bunk) belong to lower socio-economic state of class 3and 4. In children of pica group (2 and 3), none of the children of class 1 and 5% of class 2 children had blood lead (BPB) levels of >29 ug/dl whereas 72% of class 3 and 85% of class 4 children had BPB level of > 29 ug/dl.

Housing conditions (**Table - 3**) - 56% of children of children of group 2 and 3 (22/39) living in kutcha houses (i.e. improper flooring and / or walls) were shown to be more prone to lead poisoning. 43.5% children who were living in kutcha houses showed BPB level of> 29 ug/dl and in comparison only 10% of children living in pukka houses showed BPB level of >29 ug/dl.

Clinical evaluation: 80% children of group 2 and 3, and 77% children of group - 4 presented clinically with anoxia intermittent abdominal pain, constipation and diarrhoea. Headache was prominently present in of group 3 children, where as a number of parents of group 2 and 3 noted pallor. Two children of group 2 and 3, 2 children of group 4 showed definite blue line on gums. Two children of pica group showed metaphyseal densities and 2 others had faint line on long bones. Two children of group 4 also complained of metallic taste. 28 children of both the pica groups and 12 children of group 4 had more than two complaints. 11 children of group 2and 3, 5 of group 4 and 12 of control group-1 had none of the above features. More numbers of children of pica group, especially of MR group showed malnutrition and multiple vitamin deficiencies than controls and children of petrol bunk group (**Table – 4**).

Table - 3: Blood lead values Distribution in 4 groups.

Blood lead values Group, number	**<20**	**20-29**	**30-39**	**40-49**	**Ug/dl>50**	**% cases having >29 ug/dl lead levels**
Group - 1 (N=17)	3	13	1	0	0	5.8%
Group - 2 (N=7)	0	1	4	2	0	85.7%
Group - 3 (N=32)	0	17	12	2	1	46.8%
Group - 4 (N=22)	0	4	13	4	1	81%
Effect of Socio-economic class						
Class - 1 (N=17)	0	3	0	0	0	None
Class – 2 (N=7)	0	6	1	1	0	25%
Class – 3 (N=32)	0	5	10	2	1	72%
Class – 4 (N=22)	0	1	5	1	0	85%
Type of housing						
Pakka house (17)	0	13	2	2	0	10%
Kutcha house (improper walls and flooring) (22)	0	5	14	2	1	43.5%

Table - 4: Common clinical manifestation of lead poisoning in 4 groups.

Symptoms	**Group-1 (N=17)**	**Group-2 (N=7)**	**Group-3 (N=32)**	**Group-4 (N=22)**
Anorexia	2	5	8	6
Pain abdomen	1	2	10	5
Constipation	2	3	4	3
Diarrhoea	1	0	5	4
Vomiting	0	1	3	2
Headache	1	0	2	7
Metallic taste	-	-	-	2
Pallor	0	4	6	-
Blue line on gums	0	1	1	4

Some of the children had more than the one symptom. 12 controls and 5 petrol bunks workers had none of the mentioned symptoms.

Type of pica (Table - 5): Children eating mud, plaster, coal, chalk showed high blood lead levels and concomitant drop in hemoglobin level in this order of frequency. The habit of eating paper or card board had shown the least changes in biochemical and clinical parameters. However newsprint has not been separately evaluated. 24 children of group 2 and 3 were eating more than two substances. The greater the frequency and longer the duration of pica, the more was the blood lead and the lower was the hemoglobin level.

In the study, a duration of pica more than 6 months had shown a statistically significant rise of Blood Pb from 23 ug/dl -27 ug/dl, and with pica of >1 yr had shown a rise to 35 ug/dl.

Behavioral profile: 86% of group-2, 63% of group 3 and 80% of group-4.

Children scored>5 points on behavioural problem scale. Similarly 43% of group -2, 22% of group 3, and 32% of group-4, scored> 10 points. Whereas only 12% of controls scored>5 points and none scored>10 points on the same behavioural problem scale (**Table - 6**).

Psychological testing: 12 out of 22 children of petrol bunk had agreed for psychological and intelligence assessment. 4 of them showed a definite evidence of organicity and 8/12 scored less than5th percentile on ravens progressive matrices intelligence scale.

Table - 5: Influence of type of pica blood lead and hemoglobin levels.

Predominant type of pica (substances)	No of children	Blood lead levels ug/dl ± SD	Hemoglobin levels gm/dl±SD
Mud	22	35.35±7.71	9.2±1.6
Plaster	17	32.11±7.68	9.68±1.7
Coal	11	29.89±6.82	10.2±1.8
Chalk	7	31.48±8.48	10±1.8
Paint	2	31.49±6.9	9.4±1.1
Clay and stones	3	23.58±2.42	11.5±1.4
Paper	3	22.72±3.26	11.3±0.9
Others	2	25.37±4.87	11.62±1.4

Table - 6: Behavioral problems in 4 groups of children.

Group, number	Scores of behavioural problems with percentages (%)		
	<5	**6-10**	**>10**
Group-1(N=17)	15(88%)	2(12%)	0
Group-2(N=7)	1(14%)	3(43%)	3(43%)
Group-3(N=32)	12(37%)	13(41%)	7(22%)
Group-4(N=22)	4(18%)	11(50%)	7(32%)

Discussion

The impact of environmental pollution on the developing child can have damaging and long lasting consequences almost on every system in the body. Estimation of blood lead is a costly and highly skilled procedure available only in research settings in our country. This study results are analyzed by atomic absorption spectrometry with a graphite based furnace, as it is one of the most sensitive methods available in estimation of whole blood lead levels with a detection limit of 0.02- 3 ug/dl and needs only 0.1 to 1ml of blood .Blood lead level is the most dependable test of toxicity, as about 95% of lead in the blood resides in red cells, with a half-life of 35 days. The oral ingestion of lead containing material derived from the environment is the cause of lead poisoning in the majority of children. Other factors also play a role in pica, such as 1) limited parental supervision on the child, 2) previously existing brain damage in the child, 3) parental lack of knowledge of the consequence of the ingestion of such items. In this study, higher blood lead are observed in lower socio-economic group and children who are living in poor housing conditions, which provides environmental conditions that expose the child to high risk for lead poisoning. Children with pica have shown higher Lead levels and lower haemoglobin levels than controls. The differences are much more significant in MR children that these children have more frequent and persistent habit of pica, and also more prone to parental negligence.

The essential factor in lead poisoning is the availability of materials containing lead. Paint is a rich source of lead. In the western countries cause of inorganic lead poisoning in child pica are paints peelings, chips from interior and exterior surfaces of house and window shelves. More ever in India it is not an important source, as the use of paint in interior decoration is a rare practice. In this study major causes of lead poisoning were mud, plaster and coal than paint. Ingestion for prolonged periods will produce significant lead toxicity. This study revealed a statistically significant difference in blood lead levels between study group having pica for than 6 months duration and controls.

In the present work, children with pica had abdominal colic, diarrhoea etc., they also had higher blood lead levels, lower hemoglobin values, higher incidence of nutritional and vitamin deficiencies than children in the controls. These results are comparable with other studies. In concordance with other western as well as Indian studies behavioural problems are more frequently observed in children with pica much more so in MR children than controls.

Occupational exposure is another important cause of lead toxicity in child laborers, especially those who are working in printing, battery sheltering units, automobile garage and petrol bunks. These children acquire lead toxicity by way of

- Inhalation of fumes of evaporated petrol.
- By constant absorption of organic lead through skin.
- And by oral ingestion of lead due to improper hand washing and poor hygiene.

In this study, children working in petrol bunk showed a high mean blood lead levels of 35.8ug/dl and lower hemoglobin levels than controls which is statistically significance with a 'P' value of <0.001. The majority of children similar to children of pica group complained of headache, anorexia, two children showed definite blue line and other two showed a faint interrupted blue line on gums. Whereas nutritional and vitamin deficiencies are less often seen in this group than pica children. 80% of children of petrol bunk group showed behavioural problem in equal with the pica group. 4 children (out of 12) stood < 5th percentile level on Ravens progressive matric intelligence scale.

Environmental pollution by automobile exhausts and industrial discharges are major cause of lead toxicity in children, apart from habit of pica and occupational exposure to lead (khandekar, et al.) in a study conducted on children in new Delhi concluded that petrol exhaust contributed to rise in blood levels. An alarming result of this study is – high blood levels in children of control group of Hyderabad city. The mean blood lead level of 23 ug/dl (range 18-28 ug/dl) which is very high when compared to the geometric mean of other parts of country. The mean blood lead level of children of industrial areas of Bombay reported by Khandekar, et al. [5] is 11.3 ug/dl (range 1.1 - 47.7ug) and children of Delhi city reported by S.T. Gogte, et al. [6] mean Blood Pb levels of 9.6ug (range 8-33 ug/dl).

Basophil stippling and x-rays of long bones did not consistently help in detecting high blood lead levels. The former depends on hemopoietic rate and therefore, anemia due to other nutritional deficiencies may suppress it. Lead line in growing epiphysis of long bones requires a longer exposure to high levels of lead and may not manifest in its recent cases. However this investigation can be easily conducted in small hospital and should be avails, taking care not to exclude plumbism if results are negative.

May studies as Rabinowitz, et al. [7] enrolled 249 newborns in Boston to determine correlates of BLLs. They reported that the strength of association between environmental lead and BLL increased with age, but demographic variables such as race, maternal age and education, and gender did not predict BLLs. In a study in 1- to 5-year-old Mexican children (*n* = 371), geometric means of BLLs did not show significant variation by age, sex, occupation, and education of mother. BLLs were associated only with the use of lead-glazed pottery dishes in the household and the habit of biting colored pencils among children in study Lopez-Carrillo, et al. [8]. However, Sargent, et al. [9] in their study of children from birth to 4 years of age in Massachusetts reported various socio-demographic and housing characteristics to be significant independent predictors of lead poisoning (defined as BLL ≥25 μg/dL). Potula and Hu [10] assessed occupational and lifestyle determinants of BLL in 129 adult men in Madras, India. They reported that a nonvegetarian diet and job category were significant predictors of BLL. Other studies on the extent and sources of lead pollution in India have also been performed. (Awasthi, et al. 1996; Chatterjee and Banerjee 1999; Dwivedi and Dey 2002; Friberg and Vahter 1983; Gogte, et al. 1991; Tripathi, et al. 2001) [11-15].

Conclusion

The present study suggests that oral ingestion in an important route of inorganic poisoning in children with pica, whereas inhalation through respiratory passages and absorption through intact skin is an important route of organic lead poisoning in children working in petrol bunks or automobile garages-by virtue of their occupation. Geometric mean blood lead level of children of Hyderabad city is higher than Bombay, New Delhi and other western cities.

This work suggests that lead poisoning should be suspected,

- In children with pica with multiple objects especially if they are retarded, and belongs to lower socio-economic status and living in poor housing conditions.
- In children with history of occupational exposure
- Anemia with or without basophil stippling
- Lead lines on long bones.

An attempt should be made to remove the source from their environment. Nutritional and vitamin deficiencies and anemia should be corrected. Oral pencillamine for short term and thiamine for long term tried as a therapeutic test for clinical improvement because blood lead cannot be estimated in most of the Indian hospitals. There is a need for urgent political will and administrative action to control the level of environmental pollution through promulgation of appropriate laws and their strict implementation. If immediate action is not taken, this problem, because of its insidious nature and obvious difficulties in its detection, will achieve the proportions of major environmental disaster by the time it is clinically obvious. But by then remedial action will be difficult, time consuming and a challenge to any sophisticated health care system at that time. In contrast, primary preventive measures instigated at this juncture will not only avert a major ecological disaster, but also significantly reduce the burden on our health services.

Child labour, a social problem in India should be condemned. Regional and national welfare organizations should work to restrain children from taking up such hazardous occupations. As a part of primary prevention of environmental contamination, government should introduce lead free petrol and action must be taken to implement better technical control measures such as effective exhaust ventilation, disposal of dust and effluents containing lead. Moreover, such industries should be banned from being operated in residential areas.

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