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Study on lead exposure among school going children in Uttarakhand region and correlating blood lead levels with haematological and physiological parameters.

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Abstract

Aim: Children are exposed to chemicals in consumer products, household dust, food, air, water, and soil, some of which might interfere with healthy brain development, causing long-lasting neurodevelopmental effects. Children are still being exposed to lead despite of evidence of the adverse impact of lead exposure, even for children with blood lead levels below the currently recognized threshold for intervention.

Methods: We identified and determined the blood lead and Haemoglobin levels in children aged upto 12 years residing along the Rispana River in Dehradun in order to assess the effects of Lead (Pb) exposure. The study included 92 total subjects. Blood lead and haemoglobin levels were measured in blood samples of all subjects and Standard Deviation (SD) as well as p value was calculated by statistical analysis.

Results: The p value for blood lead levels in cases and controls was statistically significant. The blood lead levels were higher in male subjects and children having weight <30 kg, p value for which was also statistically significant Probability (P) value for haemoglobin among cases and controls was borderline significant.

Conclusion: Lead exposure among children residing along the Rispana River has caused significantly high blood lead levels especially in male children. In addition to this, the haemoglobin of children getting exposed to lead is slightly lower than other subjects. The most significant source of lead exposure in children is consumption of tap water. This shows the detrimental effect of environmental heavy metal exposure in children.

Keywords: Lead toxicity, Contamination, Exposure, Children, River

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Introduction

Toxicity by lead and other potentially toxic molecules and elements is a growing global issue that has been always fraught with challenges due to its adverse effects on public health. Mental retardation of more than 0.6 million children worldwide is attributed to blood lead levels annually. Over the past 30 years regulatory and environmental reforms in the developed world have significantly ameliorated lead pollution among children. However, in developing countries the environmental lead level and ways to reduce and prevent exposures are only beginning to be understood. A couple of previous cohort studies done in children during 1980s in North America, Europe, and Australia documented that blood lead concentrations of at least 10 µg/dl are inversely associated with cognitive test scores in children and these findings led to the 1991 revision of the Centres for Disease Control and Prevention's (CDC) definition of an elevated blood lead concentration, which was lowered from 25 to 10 µg/dL [1-3]. Lead poisoning is one of the major environmental diseases among children in developing countries. Exposure to even extremely small amounts of lead can have long-term and slowly accumulating deleterious effects in children.

Lead is found in all parts of the environment, it is derived from human activities such as mining, manufacturing, and burning fossil fuels, from drinking water where lead pipes are used, incineration of lead-containing waste such as electronic waste, and lead contaminated food chain system through lead-contaminated soil etc. The most common sources of lead exposure to children from the environment are gasoline, active industry, lead- based paint sand pigments, food cans, ceramic glazes, drinking water systems using lead pipes, lead-containing traditional and folk remedies, cosmetics, toys [4-8]. Some healthcare products and folk remedies also contain lead. In a prospective study from urban Vellore (Tamil Nadu, India), nearly half of the children having a piped water supply and mud or clay floors in the house were significantly associated with elevated blood lead levels [9].

Lead is a well-known non-biodegradable toxic metal in the environment and it has become a global health issue [10,11]. Lead affects almost every system in the body. It shows deleterious effects on the nervous, renal, and reproductive systems and causes a high blood pressure. Apart from this, it affects growth and development, psychological behaviour, and intelligence [12-16].

Blood lead levels rise rapidly after a recent exposure only. Lead is a purely toxic element and theoretically its levels in any body fluid should be zero, which is not possible in an industrialized society. The acceptable level at which no adverse effects are seen is 10 µg/dL for children and 25 µg/dL for adults. Acute lead toxicity is apparent by blood lead level of 120 µg/dL in adults and 80µ/dl in children and may irreversibly give rise to increased cerebrospinal pressure, convulsions, memory loss, acute encephalopathy and death. Blood levels as low as 25 µg/dL may produce neurotoxic effects such as dullness, irritability, restlessness, poor attention span, headache, muscular tremor, hallucinations and memory loss. Children are most sensitive to lead than adults because of their developing central nervous system, smaller body size, higher rate of absorption and tendency to put objects in their mouth. Previous studies with evidence from animal-model, and human observational studies suggest that childhood lead exposure may raise the risk of adult neurodegenerative disease, particularly dementia, through a variety of possible mechanisms including epigenetic modification, delayed cardiovascular and kidney disease, direct degenerative Central Nervous System (CNS) injury from the lead remobilized from bones, and lowered neural and cognitive reserve [17,18].

Rispana, a river flowing through middle of the Dehradun city (Uttarakhand, India) is gradually decreasing in its water content and a large population has been inhabited around it in recent years. The narrowing of river has raised the content of pollutants in it including heavy metals such as lead. The toxin levels in the waters of three main rivers-Rispana, Bindal and Suswain Dehradun exceed the standard Central Pollution Control Board (CPCB) limit, concluded in a study by Dehradun based Society of Pollution and Environmental Conservation Scientists (SPECS).

The study reveals that level of toxins like lead, fluoride as well as nitrate and phosphate is way above the standard limit. "While CPCB says that the Nitrate level should be 0 mg/L, it was found to be as high as 496 mg/L in Bindal, 503 mg/L in Rispana and 517 mg/Lin Suswa. All these toxins ultimately reach Ganga as all the three are tributaries of it [19]. The effect of lead on haemoglobin synthesis leading to anaemia over chronic exposure has also been documented previously [20].

This present study, therefore, was conducted to analyse the lead exposure of children aged up to 12 years residing nearby the Rispana River. Since it has known that lead has a direct inhibitory effect on heam synthesis, estimation of haemoglobin was also performed for better understanding of lead induced anaemia and correlate environmental lead exposure and deleterious effects on child health.

Materials and Methods

The study was conducted in year 2019 in the Department of Biochemistry, at Shri Mahant Indresh Hospital associated with Shri Guru Ram Rai Institute of Medical and Health Sciences, Patel Nagar, Dehradun (Uttarakhand, India). This study analysed 92 children including 58 controls and 34 cases, having both male and female school going children aged <12 years. The investigations were carried out at National Referral Centre for Lead Poisoning, Department of Biochemistry and central laboratory of Clinical Biochemistry of Shri Mahant Indiresh Hospital. Blood sample were obtained by vein puncture from all the cases as well as controls.

Collection of blood samples and estimation

A successful lead awareness camp was organized at Shri Guru Ram Rai Inter college, Mothrowala, Dehradun (Uttarakhand) in the year 2019 and 2020. Also, pamphlets showing awareness regarding lead toxicity and its prevention were distributed to children with the support of Uttarakhand Science Education and Research Centre (USERC).

A signed informed consent was taken from all subjects. About 5 ml of venous blood from all subjects was collected aseptically from anti-cubital vein in heparin or Ethylene Diamine Tetraacetic Acid (EDTA) containing vial. Whole blood was used for the estimation of blood lead (Pb) levels and haemoglobin level. Lead estimation was performed on lead care 2 systems. The lead care 2 system relies on electrochemistry and a sensor to detected lead in the whole blood. Most of the lead is carried in red blood cells. When a sample of whole blood is mixed with treatment reagent, the red blood cells are lysed and the lead is made available for detection. The lead care 2 kit includes capillary tubes for the collection of whole blood sample directly from the patient's finger. The system is also compatible with venous samples. Proper preparation of the puncture area is important as per CDC guidelines. Haemoglobin was estimated in fully automated coulter counter which is based on the principle of reflected photometry.

Statistical analysis

The data obtained was coded and entered into Microsoft Excel Worksheet. The categorical data was expressed as rates, ratios, and proportions and comparison was done. The continuous data was expressed as mean ± S.D and the comparison was done. A probability value (P-value) of less than or equal to 0.05 was considered as statistically significant.

Results

The demographic (Age, Height, Weight) and clinical (Blood Lead level, Haemoglobin, Systolic BP, Diastolic BP) characteristics of two groups (cases and controls) is summarized in Table 1, comparing the mean demographic and clinical characteristics of two groups, t test showed significantly higher (P<0.05 or P<0.001) for blood lead level.

The mean value of blood Lead level and Haemoglobin in male and female children group (cases and controls) is shown in Table 2. The blood lead was higher in male cases 7.22 ± 3.34 *vs.* controls 3.59 ± 0.65 and female cases 6.34± 1.37 *vs.* controls 3.54 ± 0.68, which is statistically significant with P<0.001when compared to control groups.

The mean value of blood Lead level and Haemoglobin in female children group (cases and control) is shown in Table 2. The increase in mean blood Lead level in cases is statistically highly significant with P<0.001when compare to control groups.

The mean value of blood Lead level and Haemoglobin in children with body weight <30 kg (cases and controls) is shown in Table 3. The increase in mean blood Lead level in cases is statistically highly significant with P<0.0001 when compare to control groups and the mean of haemoglobin level in cases is statistically borderline significant with P<0.05 when compare to control groups.

Table 4 depicts the percentage lead exposure in various sources of lead obtained from the history of the subjects. Out of 58 children with blood lead levels <10 µg/dL, 05 (07%) children were anaemic and remaining 53(93%) had haemoglobin >11 g/dL and out of 34 children with blood lead level >10 µg/dL, 05(13%) children are anaemic and 28(87%) were not anaemic. Among other criteria, lead exposure expressed in percentage is maximum in the children who use tap water, and much less in children who use other sources of water (like hand pump and RO purified water), followed by in children who live nearby the river, and in children who use cosmetics in daily life.

Table 1. *Mean and Standard Deviation (Mean ± SD) values of case and control groups.*

Parameters	Case (N=34) Mean ± SD	Control (N=58) Mean ± SD	P-Value (<0.05)
Age	11.71 ± 0.52	11.86 ± 0.44	0.1438
Weight	36.26 ± 6.51	37.88 ± 5.00	0.1839
Height	143.03 ± 8.36	146.60 ± 8.76	0.0582
Systolic BP (Blood Pressure)	112.12 ± 7.53	113.41 ± 7.71	0.4367
Diastolic BP (Blood Pressure)	74.18 ± 5.74	76.40 ± 5.34	0.0644
Lead level (µg/dL)	6.86 ± 2.71	3.56 ± 0.66	<0.0001**
Hemoglobin level (gm/dL)	12.20 ± 1.27	12.48 ± 1.04	0.2542

Table 2. *Mean and Standard Deviation (Mean ± SD) value of male and female children case and control group.*

Parameter	Case Male (N=20) Mean ± SD	Control Male (N=30) Mean ± SD	Case Female (N=14) Mean ± SD	Control Female (N=28) Mean± S	P-Value (<0.05)
Lead level (µg/dL)	7.22 ± 3.34	3.59 ± 0.65	6.34± 1.37	3.54 ± 0.68	<0.0001**
Haemoglobin level (gm/dL)	12.86 ± 0.83	13.01 ± 0.83	11.28 ± 1.22	11.90 ± 0.94	0.5343

Table 3. *The mean and standard deviation (Mean ± SD) value of case and control on the basis of weight (<30 Kg).*

Parameter	Case Male (N=07) Mean ± SD	Control Male (N=07) Mean ± SD	P-Value (<0.05)
Lead level (µg/dL)	6.60 ± 1.08	3.54 ± 0.71	<0.0001**
Haemoglobin level (gm/dL)	11.97 ± 1.09	12.87 ± 0.15	0.0513

Table 4. *Percentage of lead exposure on the basis of other criteria.*

Criteria	Case (N=34)	Percentage of lead exposure	Control (N=58)	Percentage of lead exposure
Residing nearby river	22	65%	32	55%
Uses of tap Water	30	90%	53	93%
Uses of RO Water	01	3%	01	2%
Uses of hand pump water	01	3%	01	2%
Uses of cosmetics	17	50%	31	54%
Uses of toys and other utensils	02	6%	03	6%
Others sources	02	6%	02	4%
Anemic children	06	13%	05	7%
Non-anemic children	28	87%	53	93%

Discussion

In developed countries, different international lead poisoning awareness prevention programs have been conducted to reduce the exposure of lead to children and traffic police. World Health Organization (WHO) launched an international lead poisoning awareness prevention week themed on lead free kids for a healthy future, which underscored the importance of avoiding the use of lead paint and replacing it with safe alternatives in order to prevent children from lead poisoning (WHO 2013).A report by Times of India (2018) stated that the rivers of Dehradun like Rispana, Bindal, Suswa has seen 10-15% rise in the presence of hazardous chemical and pollutants as compared to previous years. This was revealed in a survey done by Dehradun-based NGO Society of Pollution and Environmental Conservation Scientists (SPECS).Around 24 samples were collected from May 8 to 19 from these water bodies which after analysis were found to contain heavy metals like chromium, zinc, iron, lead manganese and oil and grease, faecal and non-faecal coliform all of which can cause serious ailments in human beings. In 2023 a recent review published that lead-based paints are still widely utilized in many low- and middle-income developing countries and that the production and trade of lead-based paint are still widespread globally. From the review article they believe that the accompanying approach of international organizations and their strategies to reduce lead levels in paint is leading to critical oversight, public awareness, integration system, and industry acceptance in the fight against the global lead-based paint issue.

In our study demographic and clinical characteristics of two groups (case *vs.* control) mean showed significantly (P<0.05 or <0.001) elevated lead levels in case group compared to control group. However, mean of haemoglobin showed borderline significant difference between the two groups (case *vs.* control). We found that there is no effect of lead toxicity on haemoglobin level in children.

Conclusion

In our study the mean of blood lead level was high in case group compared to control group. However, mean of haemoglobin showed borderline significance between the two groups (case *vs.* control). We have also observed that male children are more affected then female children and children having weight <30 kg was more exposed to lead. In addition to this, lead exposure to the children is maximum through tap water use. Therefore, it is the need of the hour to check the source of water supply in households settled along the banks of Rispana River. There can be alternative water supply sources in these settlements to avoid the long term dangerous effects of lead toxicity on human body, as these effects may require chronic treatment and hospitalization and thus cause a social and economic burden on the family.

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Conflict of interest

None

Ethics approval

All procedures performed in this study were in accordance with the ethical standards of the institutional ethics committee. Participants have given consent for the publication of their data.

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