

**Original article**

**Lead Exposure and Intellectual Function: Findings from Primary School Children in Bangladesh**

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**Abstract**

**Backgrounds:** About 120 million people around the world are overexposed to lead which is neurotoxic and 99 percent of the most severely affected children are in the developing world including Bangladesh. **Methods and Materials:** The present cross-sectional ecological study was carried out to explore the impact of lead poisoning on the intelligence level among 84 primary school children of a school of Bangladesh, aged between 8 and 14 years from September 2010 through January 2011. The research instrument was an interviewer questionnaire, questionnaire for IQ test and assessment of blood lead level (inductively-coupled plasma mass spectrometry with collision/reaction cells) of the study subjects after obtaining permission from their parents and the school authority. **Results:** Data were cross-checked and frequency distribution and association using chi-square test was accomplished. Background information depicted majority (69.1%) of the children aged 10-11 years (mean = 10.25 ± 1.177 yrs), female (51.2%), parents having primary level of education or below (73.8% in case of father and 77.4% in mother) and from lower socioeconomics (78.6% earned BDT 10,000 or below per month). Among all, majority (56%) were found to be moron, 27.4% in borderline, while 8.3% were imbecile with the same proportion with normal level. By their blood lead level. Majority (70.2%) had blood lead level up to 10 microgram/dl and the rest (29.8%) had more than 10 microgram/dl. Though no statistically significant association was found between IQ level of the children and their blood lead level ( $p > 0.05$ ), the health problems found among the respondents as abdominal pain (53.57%), impatience (14.29%), nausea (10.71%) and all other problems (loss of concentration to study, ear problem, anorexia and loss of weight) amounting for 21.43% are suggestive of chronic lead poisoning. **Conclusion:** Further studies in large scale with larger samples including comparative studies of inter-industrial areas have been strongly recommended.

**Key words:** Blood lead level; IQ level; children

**Introduction**

Lead is neurotoxic, and young children are at particular risk for exposure<sup>1</sup>. Numerous studies indicate that blood lead concentrations above 10<sup>2</sup>g per deciliter (0.483 <sup>2</sup>mol per liter) are associated with adverse outcomes on measures of intellectual functioning as well as with social and behavioral conduct<sup>1,2,3</sup>. Lead may impair brain development and have harmful health effects even at lower levels, and there is no known safe exposure level<sup>4</sup>. The World Health Organization estimates that 15-18

million children in developing countries are suffering from permanent brain damage due to lead poisoning. Hundreds of millions of children and pregnant women in practically all the developing countries including Bangladesh are exposed to elevated levels of lead<sup>5</sup>. Lead poisoning may be acute (from intense exposure of short duration) or chronic (from repeated low-level exposure over a prolonged period), but the latter is much more common. Children with developing physique are especially vulnerable to chronic lead poisoning because of their rapidly developing nervous systems that are particularly

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sensitive to the effects of lead<sup>6</sup>. There is no safety level of lead for children<sup>7</sup>. High quantity of lead is found in the environment as paints on the walls and doors, the playground equipments and batteries<sup>8,9</sup>. Intelligence testing as IQ (intelligence quotient) is the score of an intelligence test<sup>10</sup> and it is expected that average IQ among children in third world countries will increase if toxicity and malnutrition of various kinds get eradicated<sup>11</sup>.

With the aforesaid public health concern, the present cross-sectional study was planned and conducted to explore the impact of lead poisoning on the intelligence of the environmentally lead-exposed primary school children of Bangladesh.

**Methodology**

The present cross-sectional ecological study was conducted among children in a purposively selected school (Panpara Govt. Primary School) in an industrial area (Rajfulbaria thana in Savar district) from September 2010 through January 2011. The school was selected owing to its close proximity to the industries. Study population was children of class III, IV and V. All the children of these classes who met the selection criteria and who were present at school during the data collection time (n = 84) were taken for IQ test, blood collection and face to face interview after obtaining permission from their parents and the school authority. After aseptic precaution blood was collected for lead level. Lead level in whole blood was measured using inductively-coupled plasma mass spectrometry with collision/reaction cells (ICP-MS, Agilent 7500ce-Agilent technologies, Waldbronn, Germany). Whole blood was digested with 60% Nitric acid (HNO<sub>3</sub>) in an oven for 4 hours at 140<sup>o</sup> C. Before analysis samples were diluted with milliQ and filtered. Two commercial certified reference materials (CRMs) for blood were used for quality control (Seronorm™ Trace Elements Whole Blood L-1, REF 201505; LOT MR4206 and Seronorm™ Trace Elements Whole Blood L-2, REF 210205; LOT 1003192). A structured questionnaire was developed; its first part was designed to know the socio-economic condition from their parents. The second portion was for participants IQ test. Data was collected through face to face interview by using a pre tested questionnaire.

The children who refused to participate in the study and who were unable to provide information owing to physical or mental illness were excluded. Data were cross-checked and frequency distribution and association using chi-square test was accomplished. Before study ethical clearance was taken from Panpara Govt. Primary School committee. About instrument:

**Findings**

The socio-demographic background of the respondents, the IQ score, the blood lead level and the analyses are shown as follows.

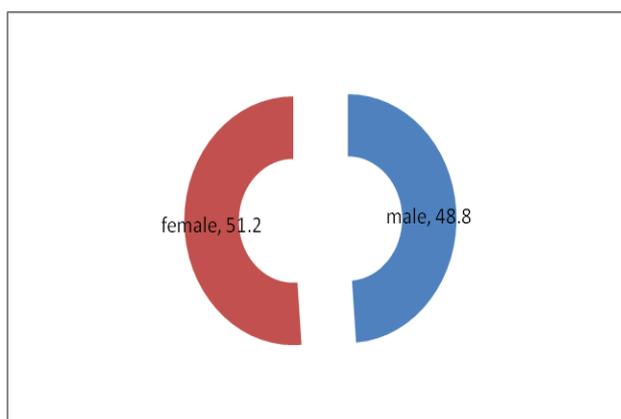
**Table I: Distribution of the children by age (n=84)**

Age of the respondents (in years)	Frequency (n)	Percentage (%)
8 -10	52	61.0
11-13	30	35.8
≥14	2	2.4
<b>Total</b>	<b>84</b>	<b>100.0</b>

*Mean = 10.25 ±1.177 years*

*Majority 40.5% (n=34) of the children were <10 years old, followed by 28.6% (n=24) who were 11 years old, while the lowest 2.4% (n=2) was of 14 years or older. The mean age was found to be 10.25 ±1.177 years.*

**Figure I: Distribution of the children by sex (n=84)**



*Among all the study subjects, female were slightly higher (51.2%) than the male children (48.8%).*

**Figure II: Distribution of the children by their father’s educational level (n=84)**

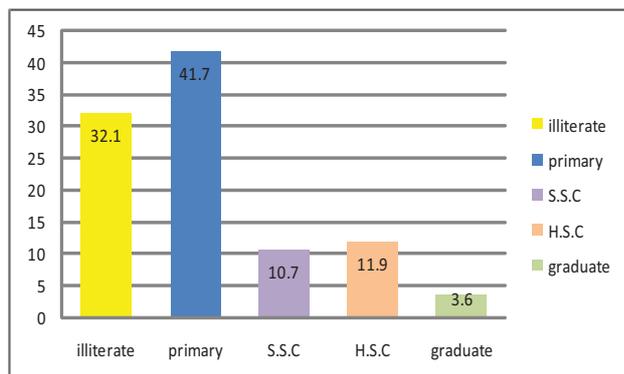


Figure II shows the distribution of the children by their fathers’ education. In majority of the cases (41.7%), fathers of the subject were found to have primary level of education. This was followed by 32.1% who were illiterate, 11.9% who had H.S.C level of education, 10.7% who had S.S.C level, while in case of only 3.6%, fathers were found to be graduate.

**Figure III: Distribution of the children by their mother’s education (n=84)**

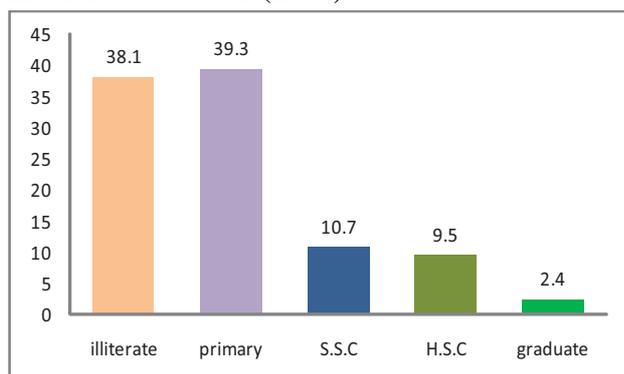


Figure III shows the distribution of the children by their mothers’ education. In majority of the cases (39.3 %), mothers of the subject were found to have primary level of education. This was followed by 38.1% who were found to be illiterate, 10.7% got S.S.C level of education, 9.5% with H.S.C level, while the lowest, i.e. 2.4% were graduate.

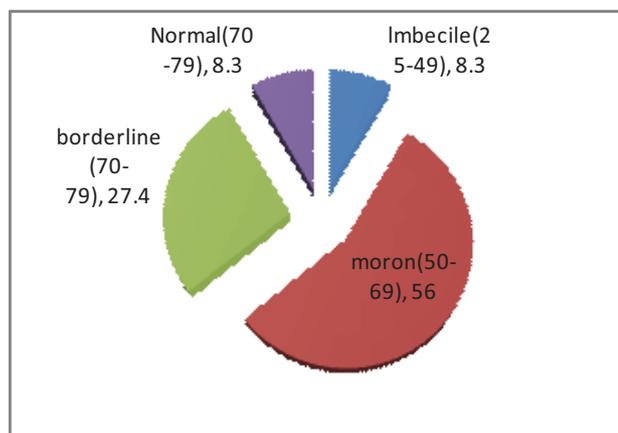
**Table II: Distribution of respondents by monthly family income (n =84)**

Income range (BDT)	Frequency (n)	Percentage (%)
<5000	45	53.6
5000-10000	21	25
10000-20000	10	11.9
>20000	08	9.5
<b>Total</b>	<b>84</b>	<b>100.00%</b>

Table II shows that out of all respondents’ parents, 53.6% had monthly income less than BDT 5000,

25% with monthly income BDT 5000-10000, 11.9% with monthly income BDT 10000-20000, while only 9.5% had monthly income more than BDT 20000.

**Figure IV: Distribution of the children by their level of IQ (n=84)**



The pie chart shows the distribution of the respondents by their level of IQ. Among the total, majority of the children (56%) were found to be moron, 27.4% in borderline, while 8.3% were imbecile with the same proportion with normal level.

**Figure V: Distribution of the children by their blood lead level (n=84)**

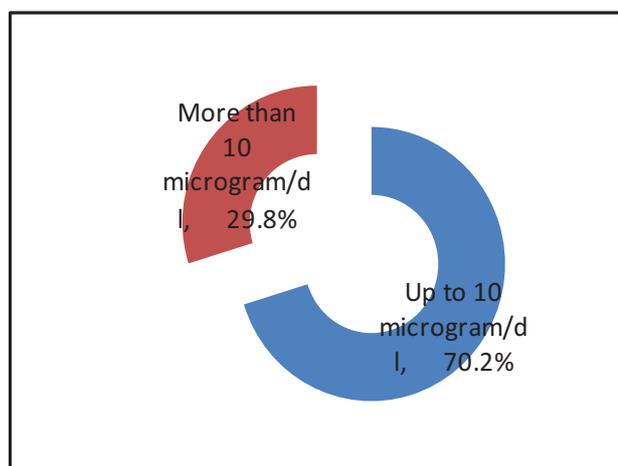


Figure V shows the distribution of the respondents by their blood lead level. Majority of the children, i.e. 70.2% had blood lead level up to 10 microgram/dl and the rest (29.8%) had more than 10 microgram/dl.

**Table II: Distribution of the children by IQ level and level of blood lead (n=84)**

IQ level	Blood lead level		Total
	Up to 10 microgram/dl	More than 10 microgram/dl	
Imbecile (25-49)	5	2	7
Moron (50-69)	32	15	47
Borderline (70-79)	17	6	23
Normal (90-109)	5	2	7
<b>Total</b>	<b>59</b>	<b>25</b>	<b>84</b>

$$\chi^2=0.262 \quad p=0.967$$

Table II shows that there is no statistically significant association between IQ level of the children and their blood lead level ( $p>0.05$ ).

**Table III: Distribution of health problems among respondents**

Health problems	Frequency (n)	Percentage (%)
Anorexia	5	8.93
Abdominal pain	30	53.57
Nausea	6	10.71
Weight loss	1	1.79
Loss of patience	8	14.29
Loss of concentration to study	5	8.93
Ear problem	1	1.79
<b>Total</b>	<b>56</b>	<b>100.0</b>

Table III shows that out of all children, 56 suffered from different ailments. Among them, majority (53.57%) was found to suffer from abdominal pain; this was followed by impatience (14.29%) and nausea (10.71%) while all other problems (loss of concentration to study, ear problem, anorexia and loss of weight) amounted for 21.43% of the respondents.

**Table IV: Distribution of the respondents on duration of their health problems (n = 56)**

Duration of health problem	Frequency (n)	Percentage (%)
2-3 months	22	39.29
6 months	16	28.57
1 year	8	14.29
more than 1 years	10	17.86
<b>Total</b>	<b>56</b>	<b>100</b>

Table IV shows that 22(39.29%) of the respondents were found to suffer from health problem(s) of any kind for 2-3 months, 16(28.57%) for 6 months, followed by 8(14.29%) for 1 year, while only 10(17.86%) for more than 1 year.

**Table V: Breast feeding of the respondents (n = 84)**

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Breast feeding	Frequency (n)	Percentage (%)
Non-exclusive Breast feeding	12	14.3
Exclusive Breast feeding	72	85.7

Table V shows that All of the respondents were provided colostrums, 12(14.3%) of the respondents did not take milk after colostrums, Exclusive breast feeding was completed by 72(85.71%) and up to 2 years by 25(29.76%) of the respondents.

### Discussion

Most industrialized countries may have adequate information about the environmental hazards as lead poisoning status of the adults as well as children, whereas such data are rare in developing countries like Bangladesh. It is difficult to ascertain the severity of the problem, because there are very few studies which may reflect the actual situation of lead poisoning among the children of Bangladesh. It may be mentioned here that childhood lead poisoning continues to be a major public health problem for certain at-risk groups of children, and concerns remain over the effects of lead on intellectual development in infants and children<sup>12</sup>.

The present cross-sectional study was conducted to explore the impact of lead poisoning on the intelligence among primary school children. Among 84 respondents, 43 were female and 41 were male. The age ranged between 8 and 14 years. More than forty percent of the children were 10 years old. Regarding age of respondents, the current study was found to be very similar with the study done by Kaiser et al<sup>13</sup> where they evaluated children at five primary schools in Dhaka to determine blood lead (BPb) levels, sources of environmental exposure, and potential risk factors for lead poisoning. Selected schools represented a range of geographic and socioeconomic strata. In a total of 779 students, 4-12 years of age participated. It may be mentioned here that childhood lead poisoning continues to be a major public health problem for certain at-risk groups of children, and concerns remain over the effects of lead on intellectual development in infants and children<sup>14</sup>.

The Centre for Disease Control has set the standard elevated blood lead level for adults to be 25 µg/dl of

the whole blood. For children however, the number is set much lower at 10 µg/dl of blood and in 2012 there were recommendations to reduce this to 5 (µg/dl)<sup>15</sup> Children are especially prone to the health effects of lead and as a result, blood lead levels must be set lower and closely monitored if contamination is possible<sup>16</sup>. In the present study we found blood level lead more than 5(µg/dl).

In the present study the socio-economic status were not so high, which were reflected by the respondents monthly family income, father's and mother's education and occupation, home material etc. More than 60 percent respondents, fathers and mother had primary level of education, SSC, HSC and graduate and thirty-two percent were illiterate. Parent's education level is a factor to IQ level of the children<sup>12,13</sup>.

In the current study, majority (about 85.71%) of the respondents had taken their mothers' breast milk for 6 months. Numerous studies report that breastfeeding is associated with higher scores on tests of neurodevelopment and cognition in later life<sup>17</sup>, suggesting that breast milk may impact early brain development, with potentially important biological, medical and social implications.

Regarding the IQ score, it was found that majority of the children (about fifty-six percent) were moron and about twenty-seven percent of the children were in borderline. The rest, i.e. eight percent were imbecile with the same proportion of normal level children. In case of blood lead level seventy percent of the children had blood lead level up to ten microgram/ dl and thirty percent of children had blood

lead level more than ten microgram/ dl (highest 65 mg/dl and lowest 4 mg/dl). In a similar type of study which was conducted on 1,333 children who participated in seven international population-based longitudinal cohort studies, followed from birth or infancy until 5–10 years of age. The full-scale IQ score was the primary outcome measure. In that study it was concluded that environmental lead exposure in children who have maximal blood lead levels < 7.5 µg/dL is associated with intellectual deficits<sup>18</sup>.

In the present study, no significant association was found in between IQ level and blood lead concentration of the respondents. Limitations of the study include small sample size (only 84 children), limited time and resources; each of which was a major constraint. The study was carried out only in one primary school in Bangladesh. Therefore, it may not reveal the true picture of the country.

### **Conclusion and Recommendations**

The present cross-sectional ecological study revealed that 56% of the children under study were found to be moron, 27.4% to be in borderline and 8.3% found as imbecile. Regarding lead level in blood, 70.2% children had blood lead level up to 10 microgram/dl, while 29.8% had it more than 10 microgram/dl. Though no statistically significant association was found between IQ level of the children and their blood lead level, respondents were found to suffer from health problems suggestive of chronic lead poisoning. Therefore, further studies in large scale with larger samples are strongly recommended among children residing in industrial areas.

## Lead Exposure and Intellectual Function

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