2 Evaluation of physical and mental development of children of arsenic exposed areas in Bangladesh

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Abstract

Physical and mental development of 157 children (age 1-5 years) from two arsenic exposed areas were studied using mothers interview and Denver Development Screening Test. The concentration of arsenic in tube well water, urine of mother and children were estimated using atomic absorption spectrometry. According to standard pediatric development milestone 8.9% were tardy in their development, and 17.8% with abnormal mental development. Arsenic in drinking water found 66.8% of study population. In urine sample of mother 30.6% had arsenic between 1-100 μg/l and 42% had arsenic >100 μg/l. Urine sample of 35.67% children had arsenic level between 1-100 μg/l and 26% had arsenic level >100 μg/l. Mean excreted arsenic concentration in urine of children was more than 3 times higher than the mean urine arsenic concentration of

their mothers. Milestone of development of children under this study was directly associated with urine arsenic concentration and difference was significant in comparison to delayed milestone of development of the children. Statistical test failed to establish significant association between arsenic exposure and mental development status of children of age group 1-5 years.

Introduction

Arsenic toxicity has become the major public health problem in Bangladesh (Smith et al., 2000). Arsenic has got various effects on human body that depends on the amount and duration of arsenic intake. Long-term exposure of arsenic is related to increase the risk of cancer in the skin, lungs, urinary bladder and kidneys as well as other skin changes such as hyperkeratosis and pigmentary changes (IPCS, 2001). Ground water is the main source of water supply in urban and rural areas of Bangladesh. To prevent the water borne communicable diseases like cholera, diarrhea, and other water borne diseases, a large number of shallow tube wells were installed through out the country to avoid those communicable diseases but unfortunately these tube wells are now created the devastating threat of mass arsenic poisoning. The people of large area of our country getting exposed to arsenic through drinking water and causing serious health effects. Approximately 30-40 million people have been chronically exposed to high concentration of naturally occurring arsenic in drinking water, supplied by approximately 10 million tube wells (British Geological Survey 2001; van Geen et al., 2003). Neurological consequences of acute and chronic exposure in adults was shown (Rodriguez et al., 2003), although the dosimetry is poorly described. Clinical and industrial reports of heavy exposure in adults (Bolla-wilson and Bleecker 1987; Morton and Caron, 2003) document adverse impacts on a range of cognitive functions; including learning, memory, and concentration, as well as peripheral and central neuropathies (Morton and Dunnette, 1994; Pershagen et al., 1981; Schoolmeester and White, 1980). Concha et al., (1989) also reported that maternal infant pairs exposed to high arsenic concentration in drinking water represents similar arsenic concentration in cord blood and maternal blood. Death of fetus due to arsenic poisoning in pregnant mothers was accompanied by toxic level of arsenic in fetal organs (Lugo et al., 1969). The above-mentioned studies reveal that, arsenic crosses the placental layer. We assume that, high arsenic concentration in cord blood and in breast-milk of lactating mothers may hamper fetus and childhood development.

Millions of people in Bangladesh are at risk to develop arsenicosis, of which a greater number are female of reproductive age. It is reported that arsenic has detrimental effects on pregnancy as well as in child health. Environmental exposure of lead or manganese in children is associated with intellectual deficits (Lanphear et al., 2005; Schnaas et al., 2006; Wasserman et al., 2006). This study is designed to assess childhood development status of children of arsenic exposed mothers between the ages 1-5 years and compare the findings with matching group of children of unexposed mothers.

Methods and Materials

Study area: Babutipara village of Muradnagar Upazilla (Comilla District) and Shompara village of Chatkhil Upazilla (Noakhali District) were selected purposively to conduct this study.

Duration of study: This cross-sectional study was conducted during January 2005 to March 2006.

Study population: Initially non-biased 200 children between the ages 1-5 years along with their mothers were selected to evaluate physical and mental development. If one mother had more than one child between above-mentioned age group, we selected the eldest one. Inclusion criteria were a) children at the age of 1-5 years irrespective of sex, b) children and their mothers willing to participate, and c) children who are able to participate. Exclusion criteria were a) children at the age of 1-5 years with both physical and mental disability and b) children and their mothers not willing to participate.

Development of questionnaire and field testing: Required information was collected through pre-designed questionnaires. There were 3 parts of the questionnaire namely general information, obstetric history and clinical examination of mother and child. The questionnaire was developed in English and translated in Bengali. For validation of translated questionnaire it was translated back by a separate person. At the time of orientation training of interviewers the questionnaire was field-tested. The strength and weakness of the questionnaire were discussed and the recommendations were incorporated in the final set of questionnaire. For assessment of mental developmental status of children we used Denver Development Screening (DDS) test (Frankenburg et al., 1971).

Supervisors and interviewers: Two supervisors were selected from the local areas. Both the supervisors had previous working experiences with research team. Local supervisor of Babutipara belongs to an "arsenicosis self-help" group. Supervisors were assigned to collect name and address of suspected mothers and finalize the schedule of interview. Thereafter, they informed the principal investigator to visit the place for collection of necessary information/interviewing the mothers and children and the examination of children and collection of water and urine. The principal investigator used to visit the spot with her research team on scheduled date and collected information as per pre-designed questionnaire.

One pediatrician and 5 child psychologists were selected for clinical examination and assessment of mental development of children respectively. A teacher of the Department of Psychology, University of Dhaka provided training to the interviewers on specific interviewing method to assess the mental development of the children. Three interviewers were selected for collection of information from mothers according to a pre-designed questionnaire. The interviewers were trained on different technique of interview. The interviewers received hands on training on data collection procedure during pre-testing of questionnaire.

Data from mothers and children: We interviewed mothers for collection of information on age, sex, educational status, profession, socio-economic condition, location of household, number of family members, source of household and drinking water, duration of taking safe/ arsenic contaminated water, skin manifestation (melanosis, keratosis and hyperkera-tosis), obstetric history of the mother, number of children between ages 1-5 years, antenatal history, perinatal history, feeding history, etc. Pediatrician interviewed the children to collect information about Age, sex, height, weight, immunization, significant past history were recorded and conducted thorough clinical examination of the child for any pathological findings if there. The psychologist took the child in a separate room, where no other person except mother/close relative of the child was allowed to enter. The psychologist created a child-friendly atmosphere for smooth interaction of the child. They used toy, ball, pictures, playing materials, etc to make the child easy responsive. Sometimes the child used to play with the child to get easy and collect information from it. It took a lot of time to complete interview of each child. The research team gave chocolate and biscuit to the children as thanks.

Confirmation of exposure: Arsenic exposure was confirmed by taking drinking water history, laboratory investigation of water from respective drinking water source and urine of mother and child by total arsenic estimation. A dermatologist confirmed skin manifestation of arsenicosis patients by physical examination.

Collection of samples: Urine of mother and child, water from tube well were collected for estimation of arsenic.

> *Two hundred samples of urine from mothers suffering from arsenicosis, 200 samples of urine of their children and 100 samples of tube well water used by them were collected. Ten milliliters of midstream urine or 100 ml of water was collected in the container and identified as code number. All the samples were then transported to the laboratory on the same day of collection and kept it at O-4°C in the refrigerator until analysis for total arsenic. Urine samples were filtered using filter paper in order to remove epithelial cells.*

Estimation of total arsenic: Estimation of total arsenic in water and urine samples was done using atomic absorption spectrometer (AAS) with continuous flow hydride generation system (model 210 VGP, Buck Scientific Co., CT, USA). Hollow cathode lamp for arsenic with current 10 mA and wavelength 193.7 nm were used.

> *Reagents: Hydrochloric acid, sulfuric acid, nitric acid, perchloric acid, sodium borohydride, sodium hydroxide and potassium iodide were reagent grade and were obtained from E. Merck (Germany). Standard solution for trivalent arsenic (1 mg/ml) was supplied by Buck Scientific Co., CT, USA. Acetylene gas and argon were from BOL, Dhaka.*

Cleaning of sample collecting bottles and glassware: The bottles and glassware used for collection of samples and acid digestion were cleaned at first with liquid detergent and thoroughly rinsed with deionized water. These were, then, immersed in 0.1N nitric acid for 24 hours. Finally the bottles and glassware were thoroughly rinsed with deionized water, air-dried in an oven (at 60° C) overnight and ready for use.

Procedure (in brief): The method for estimation of arsenic consisted of two parts: digestion and analysis. Each sample (water or urine), at first, digested with nitric acid, sulfuric acid and perchloric acid for an hour until white fume appeared. Following digestion, each sample introduced into the hydride generator by continuous flow of 10% hydrochloric acid/3% sulfuric acid and 1 % sodium borohydride into a gas-liquid separator. The arsine vapor produced by arsenic and the hydrogen gas (produced by sodium borohydride and acid) was carried by flowing argon gas into quartz T-tube. The tube was heated in an air-acetylene flame, served as atomization cell.

Quality control: The limit of detection and limit of quantification were estimated using 3 and 10 standard deviation of low concentration of standard estimated for 6 times. Using our method, the limit of quantification of total arsenic was 0.88 µg/l.

Result

Of the initial selection of 200 cases, only 157 children were assessed properly according to DDS test. Others were dropped out due to unwillingness in doing the test and inadequate supply of water and urine samples.

Table 1 shows the distribution of children by age and sex. Average age of the children was 43.1 ± 14.3 months. Overall 55.4% of the subjects were male. Age and sex distribution of the children were homogeneous.

Table 1: Distribution of children according to age and sex

Age of child	*Sex of the child*		*Total numbers*
	Male	*Female*	
1-2 years	16	13	29
	55.2%	44.8%	
2-3 years	19	13	32
	59.4%	40.6%	
3-4 years	22	20	42
	52.4%	47.6%	
> 4 years	30	24	54
	55.6%	44.4%	
Total	87	70	157
	55.4%	44.6%	

For confirming and quantifying the exposure to arsenic at distinct tangible limit mothers' and children urinary arsenic levels were measured. Urine sample with no arsenic was ranked as 'not detectable'. Depending on the presence of arsenic in urine was grouped into not detected, 1-100 µg/l and >100 µg/l (Table 2). Out of 157 urine samples of mothers 'no arsenic' was detected in 27.4%, 30.6% had arsenic between 1-100 µg/l and 42.0% had >100 µg/l arsenic. The mean (± SD) concentration of arsenic was 31.9 ± 164.2 (ranging from non-detectable level to highest concentration of 927.0 µg/l. Out of 157 urine samples of children 'no arsenic' was detected in 38.2 % urine samples, 35.7% had arsenic between 1-100 µg/l and 26.1% had >100 µg/l arsenic. The mean concentration of arsenic was 104.7 ± 184.0 µg/l, ranging from non-detectable level to 1082.3 µg/l.

Table 2: Arsenic concentration in mothers' and children urine

Urine samples	*Urine arsenic level*			*Statistics on urine concentration (µg/l)*			
	Not detected	*1-100 µg/l*	*>100 µg/l*	*Minimum*	*Maximum*	*Mean*	*SD*
Mothers	43	48	66	0.0	927.0	131.9	164.3
	27.4%	30.6%	42.0%				
Children	60	56	41	0.0	1082.3	104.7	184.0
	38.2%	35.7%	26.1%				

Milestone of development or developmental landmark depicts the natural history of child's overall growth and development. According to standard pediatric development milestone 91.1% were found to be satisfactorily growing and 8.9 % were tardy in their development (Table 3). Comparison was sought in the urinary arsenic level of both mother and their children between children of normal and delayed milestone. Children of normal development excreted 109.1 ± 191.3 µg/l in urine whereas those of delayed development

Table 3: Comparison of milestone of development of children on urinary arsenic concentration of children and mother

Milestone of development	*Number of children*	*Statistics of urinary arsenic concentration of children (µg/l)*			*Statistics of urinary arsenic concentration of mothers (µg/l)*		
		Mean	*SD*	*SE*	*Mean*	*SD*	*SE*
Normal	143	109.1	191.3	16.0	129.6	155.2	13.0
	91.1%						
Delayed	14	60.4	67.4	18.0	155.0	245.0	65.5
	8.9%						
			t = 2.02; p = 0.049			t = -0.380; p = 0.710	

excreted only 60.4 ± 67.4 µg/l. This result was statistically significant following independent sample t test (t = 2.02; p = 0.049). Delayed development excreted less amount of arsenic in urine of mother in comparison to the mother of normal children. But the difference is not statistically significant (t = 0.380; p = 0.710).

Psychological development of children was assessed according to DDS test protocol. The protocol only provides two point general idea of childhood development whether they are with acceptable average range or not (below average). Among the children overall 82.2% were with normal mental function and 17.8 % with not normal or abnormal mental development (Table 4).

The mean urinary arsenic concentration of children with abnormal mental development was higher than urinary arsenic concentrations of children with normal mental development by 63.8 µg/l but the difference was not statistically significant (t = -1.67; p = 0.092). Mean urinary arsenic concentration of mother of normal mental development of children was higher than urine concentration of mother of children with abnormal mental develop ment by 9.2 µg/l but the difference was statistically insignificant (t = 0.267; p = 0.790; Table 4).

Table 4: Comparison of mental development of children on urinary arsenic concentration of children and mother

Mental development	*Number of children*	*Statistics of urinary arsenic concentration of children (µg/l)*			*Statistic of urinary arsenic concentration of mothers (µg/l)*		
		Mean	*SD*	*SE*	*Mean*	*SD*	*SE*
Normal	129 82.2%	93.4	168.8	14.9	133.5	169.1	14.9
Abnormal	28 17.8%	157.2	239.3	45.2	124.3	142.4	27.0
			t= -1.67; p = 0.092			t = 0.267; p = 0.790	

Birth trauma and complication during pregnancy and delivery alone are a strong predictor of psychophysical development. No history of birth trauma and complication during pregnancy was reported in 78.3% cases. Intrauterine trauma (15.9%), eclapmsia (3.2%) and prolonged labor (2.5%) had been prevalent among the subjects (Figure 1).

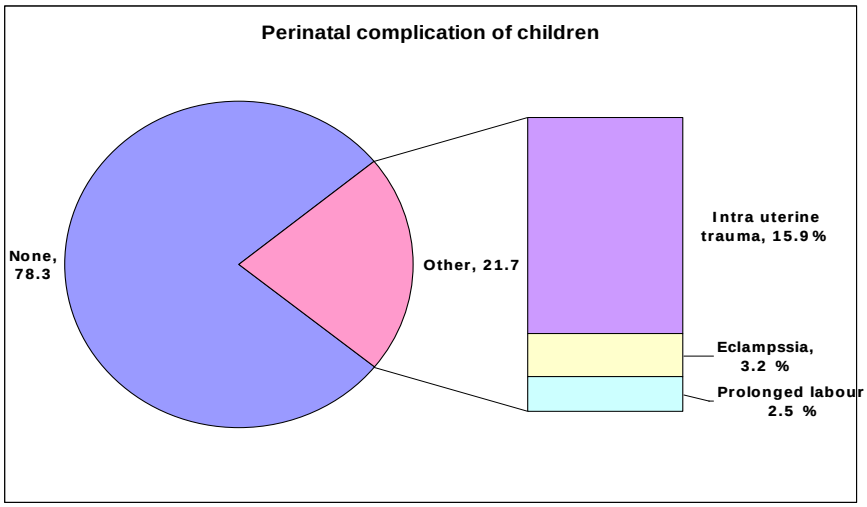

Figure 1: Prenatal complication of children (n = 157)

Table 5 shows relation between mother's occupation and mental development status of the child. Mothers' occupation were grouped into housewife and working mother with the postulation that children of working mother receive less maternal care, which might affect the nutritional status and psychophysical development. The assumption was proved null by the chi-square test ($x^2 = 0.995$; p = 0.319). Chi-square test was performed to reveal economic constrain as a contributor of mental development. Percentage of children with both normal and abnormal mental development was identical among low-income group. Table 5 further reveals that there were no association between monthly family income and mental development of the studied children ($x^2 = 1.099$; p = 0.577).

Table 5: Assessment of mental development of children on mothers occupation and monthly income of the family

Mental development of children	*Occupation of mothers*		*Monthly income of the family (Tk.)*			*Total*
	House wife	*Working mother*	*<3,000*	*3,000-5,000*	*>5,000*	
Normal	117	12	94	26	9	129
	90.7%	9.3%	72.9%	20.2%	7.0%	
Abnormal	27	1	23	4	1	28
	96.4%	3.6%	82.1%	14.3%	3.6%	
	χ^2 = 0.995; p = 0.319			χ^2 = 1.099; p = 0.577		

Among the children with history of problem or complication of any form during their pregnancy and delivery were found to be more at risk of abnormal mental development (p = 0.046; Table 6). The percentage of abnormal mental development was almost 2-fold among those who experienced problem or complication during their gestation period and delivery.

Table 6: Effect on mental development of children due to complication during pregnancy and parity of mothers

Mental development of children	*Complication during pregnancy*		*Number of parity of mothers*			*Total*
	No	*Yes*	*<3*	*3-5*	*>5*	
Normal	105	24	67	45	17	129
	81.4%	18.6%	51.9%	34.9%	13.2%	
Abnormal	18	10	12	13	3	28
	64.3%	35.7%	42.9%	46.4%	10.7%	
	χ^2 = 3.97; p = 0.046			χ^2 = 1.317; p = 0.518		

Chi-square test was performed to associate mental development with parity of mother. Percentage of children with both normal and abnormal mental development was higher among mother with <3 children. Statistical test failed to reveal significant association between parity and mental development status of children (x^2 = 1.317; p = 0.518).

Overall 39.6% of the subject were found to drink water from tube well with arsenic >50 μg/l and 60.4 % used to drink arsenic safe water.

Figure 2 portrays the distribution of the subject by age and level of arsenic exposure. In all age group the percentage of people with arsenic exposure was similar.

Samples were selected from locality of population at risk of arsenic exposure. Assessment of chronic exposure was confirmed by meticulous investigation of water source. In the context source of drinking water of subject was analyzed for determining arsenic contamination. Thus in-built control in the form of non-exposed group emerged along with the exposed population.

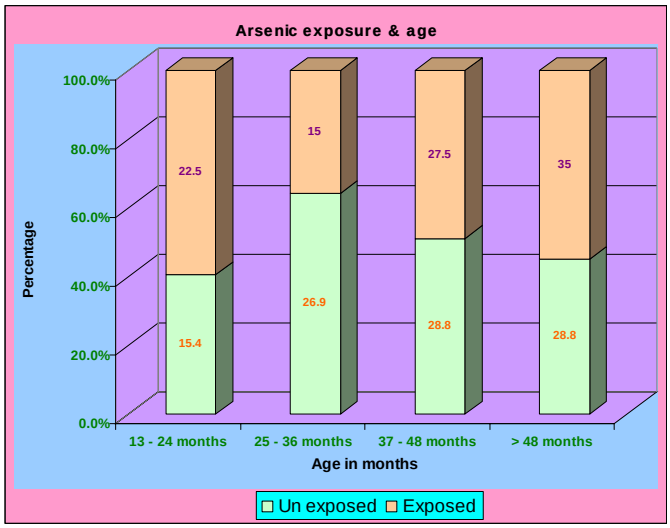

Figure 2: Arsenic exposure and age of children (n = 157)

Figure 3 shows assessment of the possible perplexing interaction of sex on arsenic exposure, difference was sought between level of arsenic in water and sex of the child.

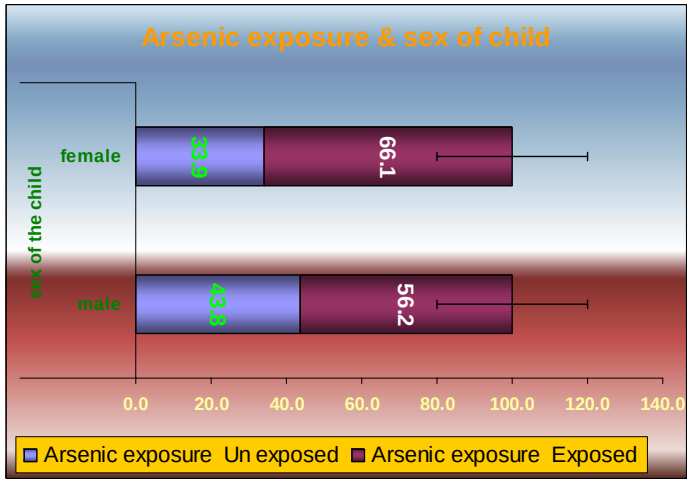

Figure 3: **A**rsenic exposure and sex of child (n = 157)

Among female 33.9% were free of arsenic exposure through drinking water and among male the percentage was 43.8. But the difference was not ample

enough to intervene the interaction of arsenic exposure with other dependent variables.

Table 7 shows the distribution of the respondents by milestone of development and arsenic in drinking water. Chi-square test was carried out to assess the potential of arsenic in drinking water in hindering achievement

Table 7: Distribution of subject by milestone of development and mental developmental status by arsenic in drinking water

Arsenic in drinking water	*Milestone of development*		*Mental development*		*Total*
	Normal	*Delayed*	*Normal*	*Abnormal*	
Un-exposed	48	4	44	8	52
	92.3%	7.7%	84.6%	15.4%	
Exposed	95	10	85	20	105
	90.5%	9.5%	81.0%	19.0%	
	$\chi^2 = 0.144$; df 1; p = 0.705		$\chi^2 = 0.318$; df 1; p = 0.573		

of milestone of development in younger subjects. Both in exposed and non-exposed subjects, majority were with normal developmental milestone. The percentage of normal children in both the groups was 92.3% and 90.5% respectively. Statistical test failed to establish an association between arsenic exposure through drinking water and milestone of development ($\chi^2 = 0.144$; p = 0.705**).** Drinking water arsenic concentration with abnormal mental development was not found higher than concentration of subjects with normal mental development and the difference was hereby not statistically significant (t = 0.318; p = 0.573).

Table 8 shows that out of 157 mothers, no arsenic was detected among 27.4% urine sample, 30.6% had arsenic between 1-100 µg/l and 42.0% had >100 µg/l. In case of children it was 38.2%, 35.7% and 26.1% respectively. Among the children of mother with urinary arsenic >100 µg/l the percentage of children with both normal and abnormal mental development was indifferent. Statistical test failed to establish significant association between mother's urinary arsenic level and mental development status of children (x^2 = 1.463; p = 0.481). Among the children with urinary arsenic concentration >100 µg/l the association between normal and abnormal mental development was nearly significant (p = 0.086).

Table 8: Mental development of children according urine arsenic concentration of mother and child

Mental development of children	*Arsenic level in children urine (µg/l)*			*Arsenic level in mothers' urine (µg/l)*			*Total*
	Not detected	*1- 100*	*> 100*	*Not detected*	*1- 100*	*> 100*	
Normal	54	45	30	35	42	52	129
	34.3%	28.7%	19.1%	22.3%	26.7%	33.1%	
Abnormal	6	11	11	8	6	14	28
	3.8%	7.0%	7.0	5.0%	3.8%	8.9%	
		$\chi^2 = 4.902$, p = 0.086			$\chi^2 = 1.463$, p = 0.481		

The presence of arsenic in urine was grouped into not detectable, 1-100 µg/l and >100 µg/l.

Table 9 states along with urinary arsenic level and drinking water history and assessment of skin lesion for confirming arsenicosis. According to the diagnostic criteria of arsenicosis patients, almost four-fifth (80.6%) was yet to develop detectable skin manifestations. This doesn't rules out the absence of exposure of arsenic in those cases. Diagnostic skin lesion was used as a landmark for confirming arsenicosis. Among the mothers 2.3% were suspected as cases and 17.0% were diagnosed as arsenicosis patients according to skin manifestation.

Table 9: Assessment of mental development of children according to arsenical skin lesion of mothers, gender distribution of children and colostrums feeding practices

Mental Development	*Distribution of mothers based on skin lesion status*			*Colostrums*		
	No skin lesion	*Suspected*	*Confirmed*	*Yes*	*No*	*Total*
Normal	104	3	22	110	19	129
	80.6%	2.3%	17.1%	85.3%	14.7%	
Abnormal	22	1	5	21	7	28
	78.6%	3.6%	17.9%	75.0%	25.0%	
		$\chi^2 = 0.161$; p 0.923			$\chi^2 = 1.757$; p = 0.148	

Table 9 further reveals that colostrums feeding status did not seem to have any of association with mental development of the studied children.

Table 10 shows that mean BMI of the children of confirmed arsenicosis patient was lower by a very slender margin and the difference is statistically insignificant as well (p = 0.070). Mid upper arm circumference (MUAC) also reveals similar scenario (p = 0.081).

Table 10: Anthropometrical measurement of children of mothers with and without skin lesion

Skin lesion status	*BMI*				*MUAC*				*Total*
	Mean	*SD*	*SE*	*Range*	*Mean*	*SD*	*SE*	*Range*	
No skin lesion	14.72	2.48	0.221	9.37-22.49	14.15	1.19	0.106	10.30-17.00	126
Suspected	13.17	1.87	0.936	11.39-15.22	13.75	0.50	0.250	13.00-14.00	4
Confirmed	13.68	2.13	0.411	9.26-18.42	13.59	1.30	0.251	12.00-16.00	27
			χ^2 = 15.803; p = 0.070				χ^2 = 3.728; p = 0.081		

Discussion

This study was designed to evaluate physical and mental development of children between 1-5 years old from arsenic exposed area of Bangladesh. No provision of control group was enshrined in the conceptual framework of the study. Drinking water sources of subjects was analyzed for determining arsenic contamination. Forty percent of studied children were exposed to arsenic concentration >50 µg/l in drinking water. Thus in-built control in the form of unexposed group emerged along with the exposed population. This study reveals that socio-economic status and mother's occupation do not have significant influence on childhood development status. In a study conducted among the children (5-14 years) of arsenic exposed and unexposed area of Bangladesh revealed that difference between nutritional status of children and income of the family was nearly significant (Karim et al., 2006).

Out of 157 samples no arsenic was detected in 27.4% of mothers and 38.2 % of children urine respectively. On the other hand 42.0% and 26.1% urine sample of mothers and children respectively had arsenic >100 µg/l; although mothers and children reported to drink water from same source. This indicates that there are some other sources to ingest arsenic in the human body. Food habit might be a confounding factor in this case. Kidney function, de-methylation capacity of individual and absorption of ingested arsenic by the body mass needs to be considered for further clarification. The study further states that there is no significant association between mothers' urinary arsenic level and mental developmental status of children.

The study finding reveals that intra uterine trauma, eclapmsia and prolonged labor have been prevalent among the subjects and the percentage of abnormal mental development was almost twofold among those who experienced such problem or complication during their gestation period and delivery. Birth trauma and complication during pregnancy and delivery alone is a strong predictor of psychophysical development.

The MUAC of children of mother with high urinary arsenic >100 μg/l was significantly higher than the MUAC of children with unexposed mother. The finding suggests that nutritional status of growing child is affected by the arsenic exposure of mother in terms of MUAC but not in terms of BMI. The finding further suggests that nutritional status of growing child is hardly interrupted by the arsenic exposure of mother, even if she develops skin manifestation.

Milestone of development was compared in the urinary arsenic level of both mother and their children between children of normal and delayed milestone of development. Comparison of children's urine (excluding "0" concentration of urine arsenic group of children) reveals that urinary arsenic concentration with normal milestone of development is higher than arsenic concentration of the children with abnormal milestone of development and the result is statistically significant. Mean urinary arsenic concentration of children with abnormal mental development is higher than urine arsenic concentration of children with normal mental development by 63.8 μg/l. but the difference is not statistically significant. Thus the study found direct correlation between milestone of development and urine arsenic concentration of children in case of psychophysical development it was inversely correlated.

In this study no association of developmental status between arsenic exposed and non-exposed children in the age group of 1-5 years was found. The nutritional status of arsenic exposed and non exposed children was not significantly difference in the age group of 5-8 years but it was significant among the age group of 9-11 years and highly significant among the age group of 11-14 years children. Wasserman et al., (2004) conducted a study among 201 children between 9.5-10.5 years old of arsenic exposed village (Araihazer) in Bangladesh and reported that water arsenic was associated with reduced intellectual function in a dose response manner. They found that children with water As levels >50 μg/l achieved significantly lower performances and full scale scores in Wechsler Intelligence Scale for children than children with water arsenic level <5.5 μg/l.

There is marked variation in arsenic-induced toxic effects. Possible factors influencing the susceptibility are genetic polymorphism (especially in metabolism), life stage at which exposures occurs, sex, nutritional status and concurrent exposure to other agents or environmental factors that influences the toxicity of the chemical. There is evidence that methylating capacity differs among individuals and population groups. Also diet poor in methionine or protein is likely to decrease the ability to methylate arsenic (Concha, 1998). Wasserman et al., (2004) performed a study of IQ test on 10 years old aged children and found water arsenic was associated with reduced intellectual function. In our study we found mental development in relation to arsenic concentration in children but in insignificant amount, possibly because of limitation described above and in the application of test required for mental development at the age of 1-5 years.

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References

Bolla-Wilson K. Bleecker ML. Neuropsychological impairment following inorganic arsenic exposure. J Occup Med. 1987; 29: 500-03.

British Geological Survey, Directorate of Public Health Engineering (Bangladesh). Arsenic contamination groundwater in Bangladesh. Final Technical Report WC/00/19 (Kinniburgh DG, Smedley PL. eds), Keyworth, UK, British Geological Survey, 2001.

Concha G, Nermelli B, Vahter M. Metabolism of inorganic arsenic in children with high arsenic exposure in northern Argentina. Environ Health Perspect. 1998; 106: 355-59.

Frankerburg WK, Camp BW, Van Natta PA. Validity of the Denver developmental screening test. Child Develop. 1971; 42: 475-85.

Karim MR, Ahmad SA, Shahidullah M. Nutritional status of children in arsenic exposed and non-exposed areas in Bangladesh. In Applied research on arsenic inBangladesh. Misbahuddin M (ed). Dhaka, Directorate General of Health Services and World Health Organization (Bangladesh), 2006, p 1-14.

Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurst P, Bellinger DC, Canfield RL, Dietrich KN, Bornschein R, Greene T, Rothenberg SJ, Needleman HL,

Schnaas L, Wasserman G, Graziano J, Roberts R. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. Environ Health Perspect. 2005; 113: 894-99.

Lugo et. Al. Arsenic (WHO Food Additives Series 18), 1969. p 570.

Morton WE, Caron GA. Encephalopathy: an unknown manifestation of workplace arsenic poisoning? Am J Ind Med. 2003; 15: 1-5.

Morton WE, Dunnette DA. Health effects of environmental arsenic. In: Arsenic in the Environment, Part II: Human Health and Ecosystem Effects (Nrigu JO, ed). New York, John Wiley and Sons, 1994, pp 17-34.

Pershagen G, Braman RS, Vahter M. Arsenic. Environmental Health Criteria 18. Geneva, World Health Organization, 1981.

Rodriguez VM, Jimenez-Capdeville ME, Giordano M. The effects of arsenic exposure on the nervous system. Toxicol Lett. 2003; 145: 1-18.

Schnaas L, Rothenberg SJ, Flores MF, Martinez S, Hernandez C, Osorio E, Velasco SR, Perroni E. Reduced Intellectual Development in Children with Prenatal Lead Exposure. EnvironHealth Perspect. 2006; 114: 791-97.

Schoolmeester WL, White DR. Arsenic poisoning. South Med J. 1980; 73: 198-208.

Smith A, Lingas E, Rahman M. Contamination of drinking water of arsenic in Bangladesh. A public health emergency. Bull WHO. 2000; 78: 1093-03.

Van Geen A, Zheng Y, Versteeg R, Stute M, Horneman A, Dhar R, et al. Spatial variability of arsenic in 6000 tube wells in a 25 km^2 area of Bangladesh. Water Resources Res. 2003; 35: 1140-50.

Wasserman GA, Liu X, Parvez F, Ahsan H, Factor-Litvak P, van Geen A, Slavkovich V, LoIacono NJ, Cheng Z, Hussain I, Momotaj H, Graziano JH. Water arsenic exposure and children's intellectual function in Araihazar, Bangladesh. Environ Health Perspect. 2004; 112: 1329-33.

Wasserman GA, Liu X, Parvez F, Ahsan H, Levy D, Factor-Litvak P, Kline J, van Geen A, Slavkovich V, LoIacono NJ, Cheng Z, Zheng Y, Graziano JH. Water manganese exposure and children's intellectual function in Araihazar, Bangladesh. Environ Health Perspect. 2006; 114: 124-29.