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Intelligence Quotient and Social Competence of Junior High School Students Drinking Arsenic Contaminated Groundwater in Bangladesh

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ABSTRACT

Bangladesh is grappling with the largest mass poisoning in human history because groundwater used for drinking has been contaminated with naturally occurring inorganic arsenic (As). Special attention is necessary to pay to the children aged 10 years or more because they are in mid of physical growth as well as mental and social development. In this cross-sectional study, 130 junior high school students (14 and 15 years old) from Narayanganj district (highly As-contaminated area) of Dhaka division in Bangladesh were selected to investigate the effect of As exposure on intelligence quotient (IQ) and social competence (SC). Visiting each student's house, information about the socio-economic status (SES) and drinking habits were collected. Urine samples were collected at school and brought back to Japan to analyze total arsenic concentration ($[As]_u$), which was used as an index of As exposure. Student IQ was assessed with the Raven's Standard Progressive Matrices test; while the Bengali version of Texas Social Behavior Inventory (TSBI) Form-A was employed for measuring SC. From the result, $[As]_u$ was significantly related with SES (especially household income). More important is that $[As]_u$ was significantly related with IQ and SC. The high $[As]_u$ group showed significantly lower IQ and SC values than the low $[As]_u$ group after SES variables were controlled. It was concluded that children's IQ and SC were affected by chronic As exposure and these adverse effects may also gradually accumulate among the poor.

Key words: Arsenic, groundwater, intelligence quotient, junior high school students, social competence

INTRODUCTION

Arsenic is one of the most common global environmental toxicants. High concentrations of arsenic in groundwater have been reported in several countries, including Bangladesh. It is estimated that about 140 million inhabitants of Bangladesh around 80 million in 61 of 64 districts are at risk of drinking arsenic contaminated groundwater (Hunter, 2001). Of these 35 million people drink water that exceed Bangladesh's guideline value of arsenic (50 μg L^{-1}) and 57 million people drink water that exceed WHO's guideline value of arsenic (10 μg L^{-1}) (Caldwell *et al*., 2006). Ninety seven percent of people in Bangladesh use tube well water for drinking and other purposes from about 8.6 millions hand tube-wells (HTWs) (Disaster Forum, 1998; Rashid, 1997). Contaminated tube-wells act as reservoirs of liquid poison, Arsenic. It has been estimated that 27%

of shallow tube-wells that is, wells not deeper than 150 m exceed Bangladesh's guideline value of arsenic and 46% of these tube-wells exceed WHO's guideline value (Smith *et al*., 2000). Arsenic concentration in drinking water might vary considerably from well to well in the same area and even in the same well at different time.

Bangladesh is one of the least developed countries in the world. There is a strong association between arsenic and poverty. The majority of victims are considered as burden to their family and society. The poor arsenicosis patients remain untreated due to financial constraints. For example, 20-70% of the patients can not receive any treatment in Bangladesh due to financial problems and most rural people cannot take any step to take arsenic free water due to their financial situation (Chowdhury *et al*., 2006a, b). Moreover, the cost of obtaining arsenic free water also diminishes household income (WHO, 2006). In addition, if the poor arsenicosis patients go for treatment, they need to spend a big proportion of their money that finally affects the household income and increases the economic burden. Besides the health effects, arsenic patients in Bangladesh suffer not only from economic burden but also from psychological suppression and social discrimination (Keya and Harun, 2008). A vast majority of the Arsenicosis patients express feelings of shame, anxiety, worthlessness, loneliness, distress, fear of death, concern for children's future particularly their daughter's marriage and blaming fate among other psychological reactions. Clinical and industrial reports of heavy exposure in adults document adverse impacts on a range of cognitive functions, including learning, memory and concentration, as well as peripheral and central neuropathies (Wasserman *et al*., 2004). Relating to mental health, very few works have been conducted on the arsenic exposure and intelligence quotient (IQ) despite its clear effect on central nervous system. However, the effect of arsenic exposure on social competence (SC) has not yet received attention and till date no study has been reported that mentioned the effect As exposure on SC of the children, so far. Besides, the affected people have right to be free from arsenic poisoning and get back the physical and mental health and honor and trust and need to be accepted as member of the community. Especial attention should be paid to the school going children, because they are growing and developing physically, mentally and socially, although mental development (e.g., IQ) is very hard to evaluate. In addition, there is an inadequacy of significant research concerning the consequences of As exposure in children over 10 years old in Bangladesh. The present study aimed at investigating IQ and SC of 130 junior high school students in grade 9 and 10 (aged between 14 and 15) at Sonargaon Thana of Narayanganj district in Dhaka division, Bangladesh. Therefore, the main focus of the present study was to investigate the effect of As exposure on IQ and SC of school going children.

MATERIALS AND METHODS

Subjects: One hundred and thirty students between of grade 9 and 10 (aged 14 and 15 years) from Sonarbangla High School were randomly selected to form the study groups comprising individuals who had been exposed to As. The subjects come from different villages in Sonargaon Thana. The average content of As in drinking water in the village was used by the urinary arsenic as the basis to form the three study groups: high-As, medium-As and low-As groups. The students from all groups lived in rural areas with similar geographic and cultural conditions and a comparable level of socio-economic development.

Study sites: Our study area was in Narayanganj district has a population of 2.3 millions and a land area of 687.74 km^2. Most of inhabitants depend on subsistence farming for the daily food

needs as opposed to market purchases and the people drinking and using groundwater through tube-wells in their daily life. The groundwater is polluted with severe arsenic poisoning.

Study design: A cross-sectional survey was conducted in the present study and a structured questionnaire was used to obtain information on socio-economic condition. Intellectual function (IQ test) of the students were estimated using Raven's Standard Progressive Matrices (SPM). Texas Social Behavior Inventory (TSBI) Form-A was used for measuring the social competence (SC).

Procedure: All children were persuaded to provide spot urine samples for the measurement of urinary arsenic, $[As]_u$. Urine samples were stored and transported on ice to the laboratory. Information on family demographics (e.g., education, occupation, income, housing type, etc.) was obtained from the interview of parents during enrollment of their children in the study. During IQ test all students, irrespective of their age, were given exactly the same series of Raven's standard progressive matrices (SPM) problems in the same order and asked to work at their own speed, without interruption, from the beginning to the end of the test. In measuring the social competence the original translated Texas Social Behavior Inventory (TSBI) scale was used to gain better results. Most of the people in Sonargaon live in houses made from tin or straw and very few of them have walls and roofs, cement or mud floors. Members of extended families live in clusters of individual houses (a bari), surrounded by family farmland. Most of them do not have own tube-wells. Some of the baris have one or more tube-wells, usually owned by a senior family member. Before conducting this study, we obtained written consent from parents and teachers from children's school.

MEASURES

Urinary measurements: Spot urine samples were collected from all students. The collected urine samples were kept in a freezer and transported to Japan where they were kept at -80°C until element determination. To determine the urinary arsenic concentration, ($[As]_u$) all procedures were done at the graduate school of medicine of the University of Tokyo. The total arsenic concentration in urine samples was determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS: Agilent 7500ce, Agilent Technologies, Waldbronn, Germany). Detection limit, calculated as the 3SD of blank signals (n = 12) to trace elements and metals as in urine were As: 0.019 μg L^{-1}. To determine $[As]_u$ concentration, the urine samples were diluted 20 times with a mixture of 1.5% HNO_3, 1.8% n-butanol and H_2O. For quality assurance, NIES CRM No.18 Human Urine (National Institute of Environmental Studies, Tsukuba, Japan), NIST 2670 Standard Reference Material (The National Institute of Standards and Technology, USA), NIST 2670 Elevated Reference Material (NIST, USA) and Seronorm Trace Elements Urine (Sero AS, Billingstad, Norway) were used as reference materials. The values obtained for $[As]_u$ felt within the range 6 to 1312 μg L^{-1}. The subjects were divided into 3 (three) groups by applying referential levels of $[As]_u$. The $[As]_u$ values of low, medium and high groups ranged from 1 to 137 (median = 59, n = 58), 138-400 (median = 221, n = 47) and 401 to 1312 (median = 653, n = 25) μg L^{-1}, respectively. According to National Institute of Environmental Studies (NIES), Tsukuba, Japan the referential levels of $[As]_u$ of 137 μg L^{-1} is so called "non-effective level" (Miyazaki *et al*., 2003) and that of 400 μg L^{-1} is relating to "dermatological level". There are more referential values especially in "non-effective levels", however, they did not change the findings observed in this study.

Children's intellectual function: Neither the WISC-III (Wechsler, 1991) nor any other recently well standardized child IQ test has been adapted or standardized for use in Bangladesh. Therefore, we assessed intelligence with the SPM which is a nonverbal test relatively free from cultural influences (Raven *et al.*, 1983). The test is made up of five sets, or series, of diagrammatic puzzles exhibiting serial change in two dimensions simultaneously. Each puzzle has a missing part, which the person taking the test has to find among the options provided. The SPM was designed to cover the widest range of mental ability and to be equally useful with persons of all ages, whatever, their education, nationality, or physical condition. The standard test consists of 60 problems divided into five sets (Set A, B, C, D and E), each made up of 12 problems (Raven *et al.*, 1983).

Social competence: A translated Bengali version of TSBI form-A by Helmreich *et al.* (1974) was used in the present study. Form-A contains 16-items in which 5-items are worded negatively and remaining 11 are positively worded. The TSBI is self-administering in nature. Subjects were requested to respond to declarative statements for which there are five response alternatives using a five-point Likert type format (not at all characteristic of me, not very, slightly, fairly, very much characteristic for me). All items are given scores ranging from 0-4 with 0 defining the response associated with low social competence and 4 defining the response characteristic of high social competence. The total score for each subject is the sum of all items giving a possible range of 0-64 with higher scores indicating higher social competence (Helmreich *et al.*, 1974).

Data analysis: Data was entered into Microsoft Excel 2007 for predicting the total scores of intelligence quotient (IQ) and social competence (SC) tests and then exported to SPSS for windows, version 17. For data analysis, the one way analysis of variance (ANOVA) was employed for predicting the differences between groups on the transformed data and the analysis of covariance (ANCOVA) also used to measure the effect of arsenic contamination on IQ and SC by controlling the socio-economic indicators.

RESULTS

In the present cross-sectional study, the respondents were asked about their present drinking water and arsenic contamination before administering the questionnaire on their socio-economic status (SES). From their oral interview, we have come to know that 53% household's tube-wells were not tested, 30% said that their drinking water is arsenic contaminated and only 17% said they are drinking safe drinking water. About the time span of using the present water, 97% of the students said that they have been drinking their present water from their early life. Prior to the present study we checked some of the tube-well's water from different villages by the arsenic test NIPSOM kit to initially assess the arsenic level. It was surprising that some of the respondent's tube-well water was in the safe range of $[As]_w$, but after getting the urine test result we found that their urinary arsenic $[As]_u$ level is high. It indicates that they are ingesting arsenic from other sources such as food stuffs. However, when we asked about the alternate water source, 74% of the respondents said they have no alternative safe water source, 22% said they are drinking water from other tube-well and only 2% said they could afford their own second tube-well.

One way ANOVA test results rejected the null hypothesis and detected that $[As]_u$ significantly differed by SES, especially by the parental occupation ($F(4, 125) = 3.32$, $p<0.05$) and income ($F(2, 127) = 9.94$, $p<0.001$). However, there was no significant relationship between arsenic contamination and other socio-economic indicators especially education, sanitation and house type.

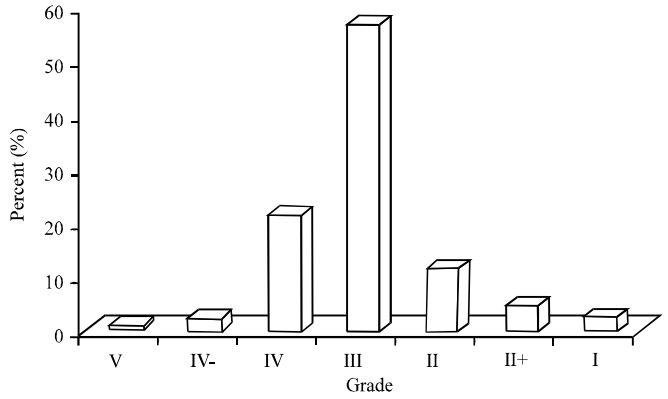

Fig. 1: Percentage distribution of IQ

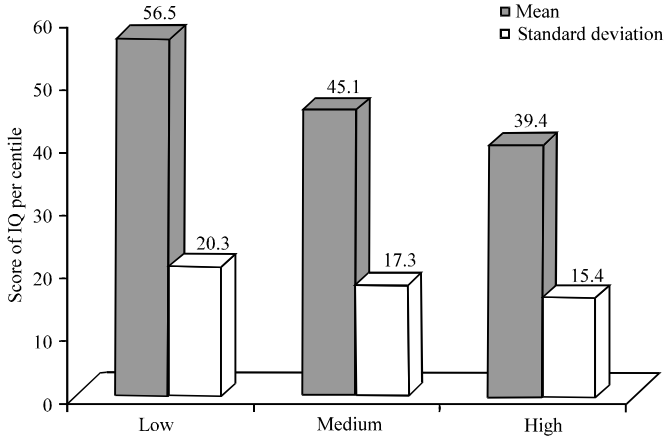

Fig. 2: Mean and standard deviation of IQ percentiles for each $[As]_u$ groups

This suggests that an individual with a higher income can take preventive measures. The present observation suggests that socio demographic condition has an influence on arsenic contamination in groundwater. Scores of IQ obtained from each subjects were computed separately. The general overview of predicted IQ scores of all students is presented in Fig. 1 and the percentage distribution exhibits nearly a Gaussian distribution. This figure also showed that 57% of the students, who lie in grade III, are average in intellectual capacity, while 12% of the students, who lie in grade II, are above the average in intellectual capacity. 5% of the students, who lie in grade II+, are high in intellectual capacity and only 2% of students, who are intellectually superior, lie in grade I. On the contrary, 24% of the students, who are in grade IV and IV-, possess below-average in intellectual capacity and only 1% of the students who are intellectually defective, lie in grade V. The predicted means and standard deviation of total score of IQ percentile for three groups are presented in Fig. 2 and it is elucidated that the mean IQ percentile (57±20.3) for low $[As]_u$ group is higher than the medium (45±17.3) and high (39±15.3) contamination groups.

The percentage distributions of IQ grades for three $[As]_u$ groups (low, medium, high) are illustrated in Fig. 3. As seen from this Fig. 3, comparatively very small percentage of students from high $[As]_u$ group possess above the average intellectual capacity (>grade III) than that of the medium and low $[As]_u$ groups. In other wards, the students from comparatively high arsenic

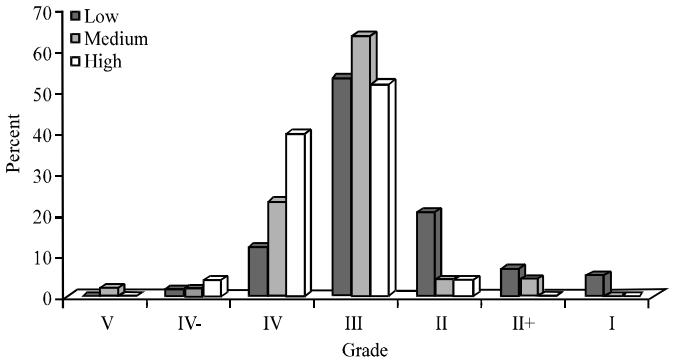

Fig. 3: Percentage distribution of IQ grades for each (low, medium, high) $[As]_u$ groups

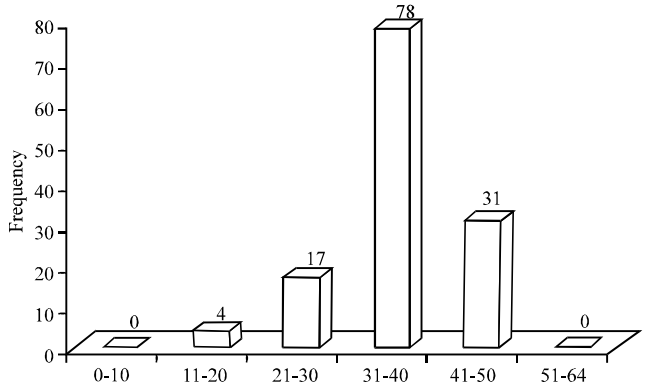

Fig. 4: Frequency distribution of SC

contaminated ($[As]_u$) group largely bearing the average and below-average IQ grades. On the contrary, higher percentage of the students from high $[As]_u$ group fall below the average IQ grade (<grade III) in comparison with the medium and low $[As]_u$ groups. Moreover, Fig. 3 also shows that more students who are from low $[As]_u$ group have possessed above-average intellectual capacity compared with the medium and high $[As]_u$ groups.

In the present study, one way ANOVA was applied for measuring the mean and variance differences. The results indicate that IQ of the students significantly differed by the $[As]_u$ groups ($F(2,127) = 9.35$, $p<0.001$). A Tukey HSD *post-hoc* test revealed that IQ percentile was lower in high (39.4±15.4, $p<0.001$) and middle (45.1±17.3, $p<0.01$) $[As]_u$ groups than in low (56.5±20.3) $[As]_u$ group illustrated in Fig. 2. However, IQ percentile in high $[As]_u$ group did not differ significantly from that in the middle $[As]_u$ group ($p = 0.424$). Finally, controlling parental education, occupation and income the ANCOVA revealed that there was a significant effect of $[As]_u$ on the IQ ($F(2,124) = 7.51$, $p<0.01$). Moreover, planned contrasts showed that the high ($p<0.001$) and medium ($p<0.01$) level of arsenic contamination ($[As]_u$) significantly lowered the IQ percentile compared to low level ($[As]_u$).

Figure 4 shows the general overview of social competence according to the predicted total score of the students. As seen from the Fig. 4, 78 of the 130 students obtained scores of Social Competence (SC) between 31 and 40 meaning that they have the average score of SC and 31 of the 130 students, who possess high level of social competency according to the TSBI, scored between 41 and 50. This Fig. 4 also shows that 4 of the 130 students, who have scores between 11 and 20, are poorly competent in the society.

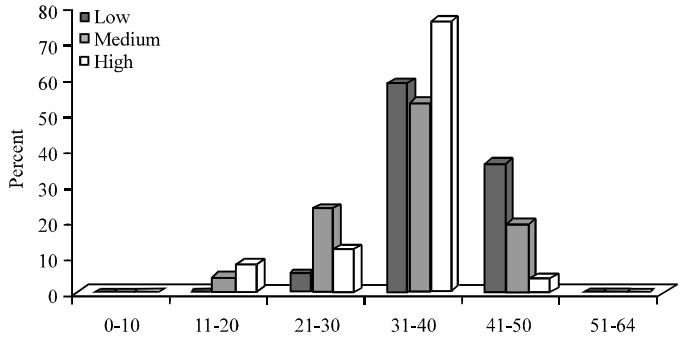

Fig. 5: Percentage distribution of total score of SC for each (low, medium, high) $[As]_u$ groups

Table 1: Mean score of SC for each $[As]_u$ groups

$[As]_u$ groups	Score of SC (Mean±STD)
Low	38.3±4.7
Medium	34.5±6.9
High	31.9±6.4

Figure 5 shows the percent distribution of total score of SC for three (low, medium and high) arsenic ($[As]_u$) contaminated groups. It is elucidated from this figure that higher percentage of students, who are averagely social competent, scored between 31 and 40 from all three $[As]_u$ groups.

A very small percentage (4%) of students from high $[As]_u$ group have possessed high social competence (scored between 41 and 50) compared with the medium and low $[As]_u$ groups. This means that the students from comparatively high arsenic ($[As]_u$) contaminated group largely scored below 40 and a very small part possess above the average score of SC in comparison with the medium and low $[As]_u$ groups. Moreover, the percentage distribution in Fig. 5 states that a high percentage of the students from high $[As]_u$ group, bearing score of SC between 11 and 20, are poorly competent in the society in comparison with the medium and low $[As]_u$ groups.

The one way ANOVA test revealed that SC significantly differed in the three $[As]_u$ groups ($F(2, 127) = 11.8$, $p<0.001$). Multiple comparisons using Tukey HSD *post-hoc* test elucidated that SC score was significantly lower in high (31.9±6.37, $p<0.001$) and medium (34.5±6.96, $p<0.01$) $[As]_u$ groups than in low (38.3±4.67) $[As]_u$ group presented in Table 1. However, the score of SC did not differ between medium and high $[As]_u$ groups ($p = 0.18$). Finally, controlling the parental education, occupation and income, ANCOVA revealed that there was a significant effect of $[As]_u$ on SC ($F(2,124) = 9.05$, $p<0.001$). Moreover, high ($p<0.001$) and medium ($p<0.01$) level of $[As]_u$ significantly lowered the scores of social competence compared to the low level of $[As]_u$.

DISCUSSION

This study was designed to evaluate the intelligence quotient (IQ) and social competence (SC) of junior high school students (aged between 14 and 15 years). Urinary arsenic $[As]_u$ was analyzed for determining arsenic contamination. From this study, we observed that socio-economic status (SES) has an influence on arsenic contamination in groundwater. Mostly rural peoples could not take any step to take arsenic free water due to their poor socio-economic condition (SEC). Therefore, the poor SEC may propagate the arsenic contamination, though some researchers state that arsenic poisoning also deteriorates the SEC. The affected people spend a big proportion of

money on treatment, often lose jobs, face barriers to access new jobs and social isolation, etc. In the present study, we found that occupation and income have an influence on arsenic contamination in groundwater. A previous study which conducted among the children (5-14 years) of arsenic exposed and unexposed areas in Bangladesh reported that the difference between nutritional status of children and income of the family was nearly significant (Karim *et al*., 2006). However, the measured IQ percentile in this study was lower in high and middle $[As]_u$ groups than in low $[As]_u$ group. On the contrary, the IQ in high $[As]_u$ group did not differ from that in the medium $[As]_u$ group. This indicates that high arsenic contamination in groundwater significantly lowered the mean IQ percentile. This may be due to the following reasons: Arsenic is neurotoxic and can damage brain functions as reported in some biomedical studies, another possibility to damage brain function in children could be caused by maternal exposure to arsenic. Evidence from a literature survey showed that toxic metals such as arsenic, lead, etc. have an influence on intelligence (IQ). Unchalee *et al.* (1999) conducted research on the association between chronic arsenic exposure and children's intelligence in Thailand. This study revealed that chronic arsenic exposure measured by hair samples was related to the retardation of children's intelligence. Wasserman *et al.* (2004) conducted a survey study on the water arsenic exposure and children's intellectual function in Araihazar, Bangladesh. They found that exposure to arsenic from drinking water is associated with reduced scores on measures of intellectual function, before and after adjusting for water Mn, for BPb and for socio-demographic features known contribute to intellectual function. With covariate adjustment, water As remained significantly negatively associated with both performance and processing speed raw scores and associations for full-scale raw scores approach statistical significance; verbal scores were unaffected. Other investigators have also observed adverse associations between As exposure and children's intellectual function. After controlling for demographic covariates, a negative association between urinary As and verbal intelligence was reported among 80 children living near a lead smelter in Mexico (Calderon *et al*., 2001). A recent small pilot study of 31 children, 11-13 years of age, residing in a former lead and zinc mining site containing tons of mining waste, or chat (Wright *et al*., 2006), found adverse associations between both hair As and Mn and general intelligence scores, particularly verbal scores. Later, Wasserman *et al.* (2007) again conducted investigation on the water arsenic exposure and intellectual function of 6 years old children in Araihazar, Bangladesh and found that exposure to As from drinking water was associated with reduced intellectual function before and after adjusting for water Mn, for blood lead levels and for socio-demographic features. Recently, Wang *et al.* (2007) conducted study on the effect of arsenic and Fluoride exposure in drinking water on children's IQ and growth in Shanyin County, Shanxi Province, China and found that children's intelligence and growth can be affected by high concentrations of As or fluoride. Rocha-Amador *et al.* (2007) have studied on the decreased intelligence in children and exposure to Fluoride and arsenic in drinking water and clarified that the children who exposed to either F or As have increased risks of reduced IQ scores. As mentioned earlier, we have measured IQ especially on the age group between 14 and 15 years old which is a representative of preadolescence age. Moreover, some biological research unveiled that 80% of the brain developed like adult until 14 years of age.

Our findings with urinary arsenic were stronger in the stratified analyses as compared to analyses that included urinary arsenic as a continuous variable. The findings with urinary arsenic as a continuous variable are strongly influenced by a small number of participants with very high urinary arsenic concentrations. However, the 95% confidence intervals of these estimates were wide. Whether or not these effects have persisting impact needs further investigation. Experiments

in vitro and *in vivo* studies provide biological evidence of the central nervous system toxicity of Arsenic. Most investigations considered short-term effects. In Rodents exposed to very high doses of Arsenic, the most common change in behavior reported was decreased locomotor activity (Chattopadhyay *et al*., 2002; Rodriguez *et al*., 2003, 2005). Various neurotransmitters have been suspected of being involved in the mechanism of arsenic neurotoxicity, but the results are conflicting (Rodriguez *et al*., 2002). Oxidative stress reactions may be involved as arsenite inhibits glutathione reductase in brain tissue (Chattopadhyay *et al*., 2002; Rodriguez *et al*., 2002, 2003). However, in vivo inhibition of glutathione reductase was only found at very high concentrations of Arsenic. Although, in the latter study, arsenic metabolites MMA and DMA were measured in brain tissue of mice, the mechanism by which arsenic crosses the blood brain barrier and the role of arsenic methylation in neurotoxic effects are not known. There was little evidence of an association between arsenic drinking water concentrations alone and intellectual function. Current urine concentrations reflecting exposure from all sources appeared to be more relevant than cumulative exposure based on measurements of water sources. One possible explanation is that the relationship with current exposure relates only to transient effects. However, it is also possible that the lack of findings with past water concentrations is due to incomplete assessment of past exposure, in particular, exposure originating from food. Although, the findings need to be confirmed, they add to the body of evidence of adverse health effects in children resulting from exposure to Arsenic.

Significant influence of arsenic contamination in groundwater was found on the SC and the score of SC significantly differed by the 3 urinary $[As]_u$ groups. However, till date no considerable work has been reported on the effect of arsenic exposure on SC, so far. Moreover, due to the As contamination most of the students said they were worried about As poisoning. Some of the children whose families were severely affected and they were negatively evaluated by others. Therefore, they felt loneliness and were isolated in the society. These factors can be influenced on SC. Finally after controlling the socio-economic status (SES) e.g., parental education, occupation and income we found that there was a significant effect of $[As]_u$ on the IQ and SC. The relationships between $[As]_u$ and IQ or SC are substantial and essential because the IQ or SC of the high $[As]_u$ group were found lower than those of the low $[As]_u$ group even when SES variables were controlled. Although, the $[As]_u$ thresholds that decrease IQ or SC are unknown, these findings imply urgent needs of conducting further investigation on mental health especially to high $[As]_u$ group, or to students drinking highly arsenic contaminated water. From the present results, it can also be understood that students who came from a family of poor SES posses comparatively low scores in IQ percentile and as well as in SC; while the children from rich SEC bears comparatively high scores in IQ percentile and SC. Therefore, it can be mentioned that there exists positive correlations between SES and IQ or SC. The relationship between $[As]_u$ and SES indicates that students with lower income parents drink more arsenic contaminated water. This is partly because inhabitants with low income cannot afford to change their tube-wells even if they know that they contain high Arsenic. Moreover, there was a significance influence of occupation on IQ or SC and the household income has a positive correlation with the occupation. Students from the occupational group 'wage labor' were mostly in average intellectual capacity (grade III) and no students in this group possessed the above average and superior intellectual capacity. Comparatively high percentages of intellectually superior and impaired students were found in the occupational group 'job'. However, although, it is difficult to predict someone's IQ and SC the present study revealed that the arsenic contamination has a significant influence on lowering the scores of IQ and SC of arsenic exposed children in Bangladesh. In addition, hypothetically it seems that children, who are intellectually

good, are socially highly competent. Therefore, the students who are intellectually good can solve problems well and actively cooperative and possess high self esteem. Our results also revealed that IQ has a significant positive influence on the social competence. From the different surveys, it was unveiled that Bangladesh is one of the highly arsenic contaminated countries in the world. However, the present survey area is a rural and one of the extremely contaminated areas in Bangladesh. The students in these survey areas are mostly came from a lower or lower middle class family. They have no ability to drink safe water from alternative source and they are still drinking the same arsenic contaminated water though they knew that their tube-well water is highly contaminated. In some villages of the present survey area, arsenic mitigation program has not yet been started. The respondents were asked about why they were using the highly arsenic contaminated drinking water and most of them said they could not afford safe water because of their poor SEC while a part of the respondent could not afford due to the distant safe water source. Some respondents said, they don't think their drinking water is risky for their health. Moreover, all the respondents were asked about their social and psychological consequences. We found out that some of the student's family members had died due to arsenic poisoning in the groundwater and 56% of the respondents are worried about arsenic contamination. The young children were worried about their future life. The respondents also explained about some of their bad experience in their social life, 2% were negatively evaluated by others. From the observations and interviews, we found out that only 1% of the students had physical symptom like melanosis. As mentioned earlier, the spot test results of water from some of the students household tube-wells indicated that their tube-well water arsenic concentration $[As]_w$ is in the safe range. However, the urinary arsenic ($[As]_u$) analysis unveiled of presenting high concentration of $[As]_u$. This phenomenon indicates that the respondents who have $[As]_w$ in safe range might have arsenic intake from other sources. These findings imply urgent needs of conducting further investigation on the effect of arsenic contamination from every possible source on the mental health of young children.

CONCLUSION

The present study showed significant association between the indicators of socio-economic status and urinary arsenic concentration $[As]_u$ and also showed that $[As]_u$ has significant association with Intelligence Quotient (IQ) and Social Competence (SC) of junior high school students in Bangladesh. It suggests that As exposure from groundwater may have influence on IQ and SC of young school going children. In the present study, it was also found that there is a significant association between IQ and SC. Our findings suggest that the increased urinary arsenic concentration reflecting current exposure from all sources, e.g., drinking groundwater, food stuffs, etc., are associated with small decrements in IQ and SC scoring. Socio-economic status e.g., parental education, income, occupation, etc. are commonly known to be associated with children's intellectual abilities as well as with social competence and we found moderate effects of occupation and income on test results. However, no significant effects were seen for other socio-demographic variables such as parental education, house type, sanitation, etc. Moreover, adjusting of socio-economic indicators it also found that high $[As]_u$ of the students led to a reduction in IQ and SC. The present survey work was conducted on a single age group at a single point in time. We do not know whether the present level of deficit can be detected earlier, whether continued exposure is associated with decreased IQ and SC, or, conversely, whether a reduction in exposure would be associated with improved IQ and SC. Better understanding of the exposure-outcome (IQ and SC) relationship could be obtained by following a group of children from an earlier age and tracking

both exposure and outcome regularly. We believe that our finding of a significant association between As exposure and IQ and SC are both important as well as tragic also. Further more, we hope that the present findings add a new sense of urgency to efforts aimed at alleviating and eliminating As exposure in Bangladesh and other part of the world where consumption of As-contaminated groundwater is prevalent.

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