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Arsenic Exposure of Mothers and Low Birth Weight

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ABSTRACT
Low birth weight (LBW) of the babies was found to be associated with arsenic exposure through consuming arsenic-contaminated water in Bangladesh. But the influences of maternal nutritional status and hemoglobin level remains to be dealt with. This study was conducted to assess the LBW of the babies in reference to arsenic exposure of mothers controlling the influences of the nutritional status (BMI) and hemoglobin level. This was a cross-sectional study carried out amongst the pregnant mothers who came to a district hospital for delivery. The mothers aged ≥18 years and had no complication were included in the study. A total of 101 mothers and their newborn babies were the study sample. Of the total 101 participant mothers, 41.5% were arsenic exposed. Comparatively, on an average, lower birth weight (2492± 477gr) was found among the babies born to arsenic exposed-mother. The exposed mother of LBW babies had significantly a higher urine arsenic concentration (381.38µg/L). The correlation analysis revealed that there was a negative relationship with the urine arsenic concentration (r=-.619; p=.000) and positive relationship with the hemoglobin level (r=.280; p=.092) and BMI (r=.204; p=195) of the exposed mother with the birth weight. After controlling the influence of hemoglobin level and BMI, an almost same association was found between LBW and urine arsenic. Mothers with arsenic exposure were at risk of giving birth to LBW babies, this could increase as evident by higher maternal urine arsenic concentration. And any positive effect of maternal nutritional status and hemoglobin level on birth weight of newborn could be offset by arsenic exposure.

Keywords: LBW, Low Birth Weight, Arsenic, Arsenicosis, Anemia, BMI, Hemoglobin

INTRODUCTION

Low Birth Weight (LBW)-is an indicator of health and nutritional status of a country. In addition, being related to a wide range of health risk for the babies, it is an important determinant of survival, growth and development. LBW not only increases the risk of dying early in life but is also responsible for the increased mortality among children [1-3]. Of all births worldwide, an estimated 15% to 20% are born with LBW. On global basis, 22 million babies were born with LBW in 2013 [4]. LBW was more common in developing countries (16.5%) than in developed countries (7.5%). The prevalence of LBW in South and South-East Asia has been reported to be 27%-28%. And globally it ranked third in terms of the number of LBW babies [1, 4-7]. The prevalence of LBW is more than 15% in many countries including the south-east Asian countries and they consider LBW as a major public health problem [1]. The countries, where LBW is a major public health problem are Mauritania (34%), Pakistan (32%), Yemen (32%), Niger (27%), Nepal (21%) and Ethiopia (20 %) [4-7]. In 2003-2004 survey, the prevalence of LBW in Bangladesh had been reported to be 36% and found comparatively higher in rural (37%) than in urban (29%) areas [2, 8]. While, in 2015 according to National Low Birth Weight Survey, the prevalence of LBW was reported to be decreased to 22.9% which is more than 15% [1], thus LBW is still a major public health problem in Bangladesh. Malnutrition of the mother, low socioeconomic status, limited access to Maternal and Child Health (MCH) services and low awareness of the people have been found to be associated with the high prevalence of LBW in Bangladesh [1,2,8-12]. However, environmental toxin as a cause of LBW has not yet been much explored in Bangladesh. Many environmental toxins have been reported elsewhere to be responsible for adverse pregnancy outcomes including LBW, and arsenic is one of them [13-17].

Arsenic contamination in groundwater and its consequences is another major public health problem in Bangladesh. About 50 million of people are at risk of arsenic exposure through drinking tube well water that contains more than 0.05mg of arsenic/L. Long-term low dose exposures to arsenic through drinking water may cause arsenicosis, the illness due to chronic arsenic toxicity. Non-communicable diseases (NCDs), as well as adverse pregnancy outcomes including LBW, are reported to be an outcome of chronic arsenic toxicity and all of these are already evident in Bangladesh [18-25]. A study conducted in West Bengal, India found a sixth fold increased risk of stillbirth in pregnant mothers having exposure to an increased concentration of arsenic (≥200 µg/L) through drinking water [26].

Nutritional status and hemoglobin level of the mother have a strong positive effect on fetal growth. Anemia in pregnancy was reported to be associated with 25% LBW [27-31]. In Bangladesh, malnutrition and anemia are widely prevalent among the pregnant women and are reported to be responsible for a higher prevalence of LBW [32-36]. A few studies could be located, that relates arsenic exposure and birth weight in Bangladesh [23, 37, and 38]. Previous studies carried out in Bangladesh on LBW amongst the arsenic-exposed mother did not consider the influence of malnutrition and anemia, and thus they might not reflect the actual picture. The current study aimed at exploring the status of LBW among the arsenic-exposed mother while controlling the influence of the nutritional status in terms of BMI and hemoglobin level of the mother.

MATERIALS AND METHODS

This cross-sectional study was carried out among the babies who born in a district hospital of Bangladesh to assess if arsenic exposure through drinking water was linked to LBW. Full term pregnant women aged 18 years or higher who came to the hospital for delivery from an arsenic contaminated area; had a history of consuming water from the same tube well water for last two years and who had not taken any sea fish in the preceding week were approached for consent to participate in the study as a respondent. Pregnant women, who had a premature birth, diabetes and other complications were excluded. Only women giving birth to a live baby along with their offspring was ultimately taken as the study participant; as a result, a total of 101 pair pregnant women and their newborn babies were included in this study. To assess the arsenic exposure status, urine samples were collected from the participating mothers. Arsenic levels of the urine samples were determined by Atomic Absorption Spectrophotometry (AAS). Anyone found to be having a urinary arsenic level of 100µg/L or more was considered as arsenic exposed and the others were considered as non-exposed. The weight of the newborn was measured immediately after birth and in the analysis stage, the birth weights were categorized as LBW (birth weight <2500gr) or Normal Birth Weight (birth weight ≥2500gr). The participating mothers were interviewed and examined for the collection of necessary information. The blood examination reports of the mother were taken from the hospital record. Height and weight of each mother was taken from the hospital record and their nutritional status (BMI) was determined. BMI of the mothers was categorized as normal (<25.0kg/m^2) and overweight or obese (≥25.0kg/m^2). Based on their hemoglobin level, mothers were categorized as anemic (Hb <11.0gr/dL) and non-anemic (Hb ≥11.0gr/dL).

Necessary ethical approval was taken from the Institutional Ethical Review Committee. Before data collection, the participant mothers were briefed about the purpose of the study and the data collection procedure. The participant mothers were also informed that their participation would be voluntary and that they were free to withdraw themselves from the study whenever they wanted to do. The participants were also assured that confidentiality would be maintained and their identity would not be disclosed.

RESULTS

A total of 101 full-term pregnant women and their newly born babies were included in the study. Among the participant mothers, 41.6% (42) were arsenic exposed (urine arsenic concentration ≥100µg/L). The age of the participants was between 18 and 32 years, they had a mean age of 21.94±3.82 years and more than one-half (53.5%) of them were below 21 years of age. Though not statistically significant, the arsenic-exposed mother had a higher mean age (22.43±4.46 years) compared to that of the non-exposed mother (21.59±3.29 years). About half of the participants (48.5%) had SSC level education and one-third (32.7%) had a primary level of education. Most of the participants (86.1%) were a housewife and comparatively a higher proportion of the non-exposed (15.3%) participants performed outside job. Almost one-fourth (23.8%) of the participants had *katcha* house and others had either tin house (49.5%) or *pucca* house (26.7%). Comparatively, a lower proportion of the arsenic-exposed participants had a tin house (42.9%) and *pucca* house (19.0%) than those of non-exposed participants and the difference was statistically significant (χ^2= 8.440; p=0.015) (Table 1).

Table 1: Arsenic exposure of the Mother and Socio-demographic characteristics

Characteristics		Arsenic Exposure		Total	Test of significance
		Yes (n=42)	**No** (n=59)	N=101	
Age (years)	Up to 20	22 (52.4%)	32 (54.2%)	54 (53.5%)	χ2=0.588; p=0.745
	21-25	12 (28.6%)	19 (32.2%)	31 (30.7%)	
	26 and Above	08 (19.0)	08 (13.6%)	16 (15.8%)	
	Mean±SD	22.43±4.46	21.59±3.29	21.94±3.82	t=-1.082; p=0.282
Education	Upto Primary	17 (40.5%)	16 (27.1%)	33 (32.7%)	χ^2=4.670; p=0.097
	SSC	21(50.0%)	28 (47.5%)	49 (48.5%)	
	HSC& Above	04 (09.5%)	15 (25.4%)	19 (18.8%)	
Occupation	Housewife	37 (88.1%)	50 (88.7%)	87 (86.1%)	χ^2= 0.231; p=0.631
	Job	05 (11.9%)	09 (15.3%)	14 (13.9%)	
House Type	*Katcha*	16 (38.1%)	08 (13.6%)	24 (23.8%)	χ^2= 8.440; p=**0.015**
	Tin	18 (42.9%)	32 (54.2%)	50 (49.5%)	
	Pucca	08 (19.0%)	19 (32.2%)	27 (26.7%)	

The overall mean birth weight of the babies was 2522±447gr and varied from 1750gr to 3550gr. The mean birth weight was found to be lower for babies born to mothers belonging of the most disadvantageous categories of the characteristics in consideration; age 20 years or less (2468gr), primary level education (2459gr) and *katcha* living house (2423gr).However, the difference of birth weights between the different categories of maternal age, education, occupation, and house type was not statistically different (Table 2)

Table 2: Newborns birth weight by Socio-demographic characteristics of the mother

Characteristics		Birth Weight (gr)			Test of Significance
		Mean±SD	Minimum	Maximum	
Age (years)	Up to 20	2468±427	1780	3250	F=.881; p=.410
	21-25	2599±485	1750	3550	
	26 and Above	2551±438	1850	3300	
Education	Upto Primary	2459±489	1750	3200	F=0.701; p=.499
	SSC	2529±401	1780	3300	
	HSC & Above	2611±490	1821	3550	
Occupation	Housewife	2516 ±455	1750	3550	t=-.290; p=.772
	Job	2554± 403	1821	3250	
House Type	*Katcha*	2423±479	1750	3300	F=0.962; p=.379
	Tin	2527±391	1780	3200	
	Pucca	2598±511	1821	3550	
Overall		2522±447	1750	3550	

In relation to the status of arsenic exposure, a lower mean birth weight was found among the babies born to the arsenic-exposed mother (2492±477gr) compared to that of the babies born to non-exposed mothers (2542±427gr) but the difference was not statistically significant (Table 3). The BMI between arsenic exposed (23.86±3.62 kg/m^2) and non-exposed (23.80±3.37kg/m^2) mothers had a little difference and not statistically significant (t=-0.103; p=0.918). However, overall mean hemoglobin of the arsenic-exposed mothers had a significantly (t=2.166; p=0.033) lower mean hemoglobin (10.25±0.852gr/dL) than that of non-exposed mothers (10.61±0.793gr/dL). Table 4 shows that a lower proportion of arsenic-exposed mothers had normal weight (38.7%) than the mothers (64.4%) who had no such exposure, but the difference was not statistically significant. Similarly, the difference in the proportion of LBW and NBW among arsenic exposed non-exposed mother was also found statistically not significant. On the other hand anemia was found to be more prevalent in arsenic-exposed mothers (59.5%) than in mothers without such exposure (39.0%) and the difference was statistically significantly (p=0.042**)**. The birth weight of the babies was examined in relation to maternal BMI and hemoglobin level (Table 5), and a significantly lower BMI (22.68±2.761kg/m^2) and hemoglobin level (10.26±0.832 gr/dL) was found among the mother of low birth weight babies compared to those of mother of normal weight babies

Table 3: Distribution of birth weight, BMI and Hemoglobin level by status of Arsenic exposure of the mot**her**

Characteristics		Arsenic Exposure		Total	Test of Significance
		Exposed	**Non-exposed**	n=101	
Birth weight	Mean±SD	2492±477	2542±427	2522±447	t=0.546; p=0.587
BMI in kg/m^2	Mean±SD	23.86±3.62	23.80±3.37	23.83±3.46	t=-0.103; p=0.918
Hb in gr/dL	Mean±SD	10.25±0.852	10.61±0.793	10.46±.833	t=2.166; **p=0.033**

Table 4: Distribution of categories of birth weight, BMI and anemia by status of arsenic exposure of the mother

Categories		Arsenic Exposure		Total	Test of Significance
		Exposed	**Non-exposed**	n=101	
Birth weight	LBW	19 (45.2%}	22 (37.3%)	41 (40.6%)	χ^2=0.643;
	NBW	23 (54.8%)	37 (62.7%)	60 (59.4%)	p=0.423
BMI	Normal	24(38.7%)	38 (64.4%)	62 (61.4%)	χ^2=0.546;
	Overweight	18 (46.2%)	21 (53.6%)	39 (38.6%)	p=0.460
Anemia	Yes	25 (59.5%)	23(39.0%)	48(47.5%)	χ^2=4.151;
	No	17 (40.5%)	36(61.0%)	53 (52.5%)	**p=0.042**

Table 5: Hemoglobin level and BMI by newborn birth weight status

Characteristics		**Status of Birth Weight**				**Test of significance**
		Low Birth Weight		**Normal Birth Weight**		
Parameter	Status	Mean	±SD	Mean	±SD	
Hemoglobin (gr/dL)	Anemia	9.59	0.525	9.88	0.546	t=-1.826; p=.074
	No Anemia	11.02	0.252	11.17	0.455	t=-1.267;p=.211
	Total	10.26	0.832	10.60	0.810	t=-2.119**; p=.037**
BMI (kg/m^2)	Normal	21.42	2.095	21.89	1.210	=-1.087; p=.281
	Above Normal	25.74	1.474	27.92	2.877	=-2.475**; p=.018**
	Total	22.68	2.761	24.60	3.689	=-2.829**; p=.006**

When birth weight of the babies was analyzed in relation to anemia and nutritional status (Table 6), a lower birth weight of the babies were found among the mother with anemia (2425±395gr) and normal weight (2451±401gr) than the birth weight of the babies of non-anemia (2609±476gr) and overweight mothers (2633±496gr) and the differences were statistically significant (t=-2.100; p=.038 and t=-2.2019; p=.046 respectively). Similarly a significant (t=-3039; p=.004 and t=-2.165; p=.034 respectively) lower birth weight was also found among the normal weight babies of mother having anemia (2744±167gr) and normal weight (2785±171gr).

Table-7 shows urine arsenic concentration of the mother in relation to birth weight, nutritional (BMI) and anemia status, it was found that exposed mothers who gave birth to LBW babies had significantly a higher level (t=4.009; p=0.000) of arsenic in urine (381.38 µg/L) compared to that arsenic level found in the urine of mother (195.62µg/L) who gave birth to babies with normal weight. When the arsenic level in the urine of the mothers was examined in relation to their BMI status and anemia, a higher level of urine arsenic was found amongst the exposed mother with anemia (311.84±203.67µg/L) and normal weight (305.93± 198.70µg/L) compared to those of non-anemia and overweight mothers but not statistically significant. In case of the non-exposed mother significantly (t=2.062; p=.044) a higher level of urine arsenic was found among the mother with anemia (43.09±26.83µg/L) compared to that non-anemic mother (29.93±21.86µg/L).

Table 6: Birth weight Newborns by Anemia and BMI status of mothers

Characteristics		**Birth Weight (gr)**					
		Low Birth Weight		**Normal Birth Weight**		**Overall**	
Status		Mean	±SD	Mean	±SD	Mean	±SD
Anemia	Anemic	2047	202	2744	167	2425	395
	Not Anemic	2059	216	2916	247	2609	476
	Significance Test	t=-.191; p=.850		t=-3039; **p=.004**		t=-2.100; **p=.038**	
BMI	Normal	2071	193	2785	171	2451	401
	Overweight	2010	237	2910	275	2633	496
	Significance Test	=0.896; p=.376		=-2.165; **p=.034**		=-2.2019**; p=.046**	

Table 7: Urine Arsenic concentration distributed by BMI, Anemia and Birth weight status

Characteristics		**Urine arsenic** (µg/L)	
		Exposed	**Non-exposed**
Status		**Mean±SD**	**Mean ±SD**
Birth weight	Low Birth Weight	381.38±188.70	36.08±26.23
	Normal Birth Weight	195.62±107.19	34.45±23.87
	Significance Test	=4.009; **p=.000**	=0.245; p=.807
Anemic	Anemia	311.84±203.67	43.09±26.83
	No anemia	232.11±109.89	29.93±21.86
	Significance Test	=1.467; p=.150	=2.062; **p=.044**
BMI Status	Normal	305.93± 198.70	34.71±25.67
	Overweight	244.64±134.17	35.68±23.01
	Significance test	=1.128; p=.266	=0.143; p=.887

A bivariate Pearson Correlation between birth weight and urine arsenic concentration was performed (Table 8) and the analysis revealed that birth weight of the babies and urine arsenic concentration of the total participants had a statistically significant (p=.001) linear relationship and the direction of the relationship was negative- that is, increased concentration of urine arsenic was associated with decreased birth weight of the babies, and the strength of association (r=-340) was moderate (Fig.1). Similar statistically significant (p=.000) linear relationship was also found between birth weight and urine arsenic concentration (Fig.2) with a negative direction and strong association (r=-.619) while analysis included only exposed mothers. But no such statistically significant (p=.188) negative relationship was found in the non-exposed mothers. On the other hand, significant linear and positive relationships between birth weight with maternal blood hemoglobin level (r=.313; p=.001) and BMI (r=.304; p=0.002) (Fig.3 and Fig.4) was found amongst the total participant mothers and mother without arsenic exposure (r=.333; p=.010 and r=.391; p=0.002 respectively). However, none of these factors had a statistically significant relationship with the birth weight of the babies born to arsenic-exposed mothers.

Table 8: Correlation between Birth weight and Urine Arsenic concentration, Hemoglobin and BMI

Birth weight Vs		Arsenic Exposure		
		Exposed	Non-Exposed	Total
Urine Arsenic	r	-.619	-.182	-.340
	p value	**0.000**	0.169	**0.001**
Hemoglobin	r	0.280	0.333	0.313
	p value	0.092	**0.010**	**).001**
BMI	r	0.204	0.391	0.304
	p value	0.195	**0.002**	**).002**

Partial correlation analysis was finally done to assess the relationships between birth weight and urine arsenic concentration after controlling the effects of BMI and hemoglobin level (Table 8). Statistically significant negative relationships between birth weight of babies and arsenic in urine of exposed mothers when controlled for BMI (r=-.601; p=.000) and hemoglobin level (r=-.599; p=.000) was found, but no such relationship was revealed in case of the non-exposed participants. However, when BMI and hemoglobin were controlled together, the partial correlation analysis further revealed a statistically significant negative relationship (r=-.587, p=.000) between birth weight and urine arsenic amongst the arsenic-exposed mother. Among the total participant mothers, similar negative relationships were also found between birth weight of the babies and urine arsenic concentration while controlling the effects of these factors (Table 9). Thus, the result of the analysis revealed that hemoglobin and BMI had a little influence in controlling the association between birth weight of the babies and arsenic in urine particularly among arsenic exposed mother

Table 9: Correlation between Birth weight and Arsenic concentrations after controlling Hemoglobin and BMI

Birth weight Vs Urine Arsenic and Control factors		Arsenic Exposure		
		Exposed	Non-Exposed	Total
BMI	r	-.601	-.169	.327
	p value	**.000**	.206	**001**
Hemoglobin	r	-.599	-.119	.282
	p value	**.000**	.372	**004**
Combined	r	-.587	-.114	.227
	p value	**.000**	.398	**005**

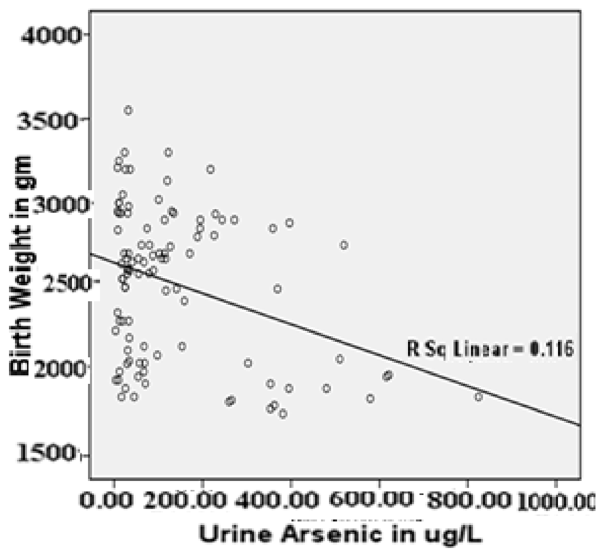

Fig. 1: Correlation between birth weight and urine arsenic

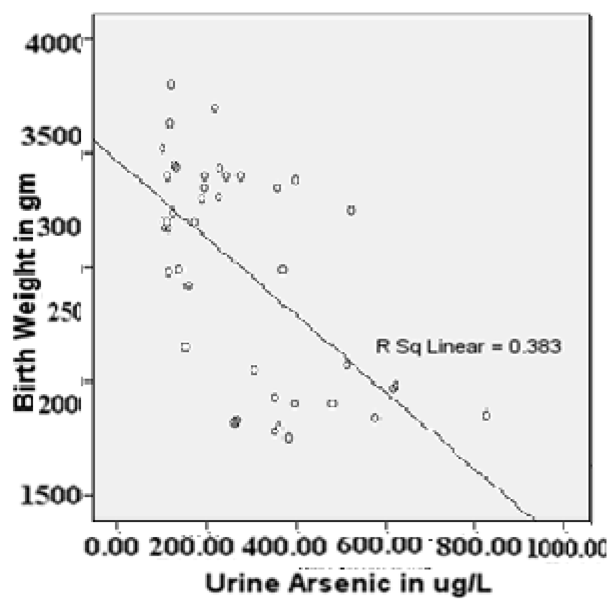

Fig. 2: Correlation between birth weight and urine arsenic of exposed mother

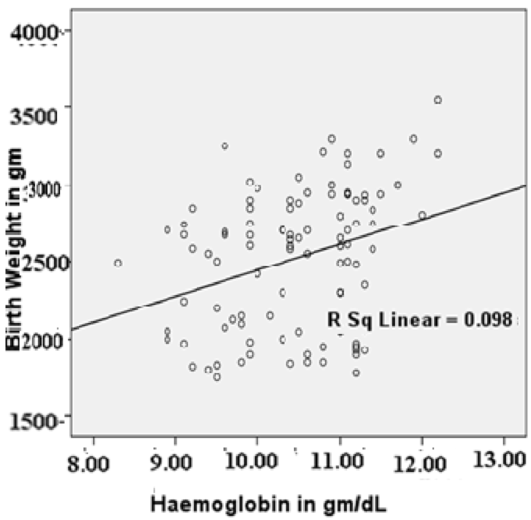

Fig. 3: Correlation between birth weight and hemoglobin level

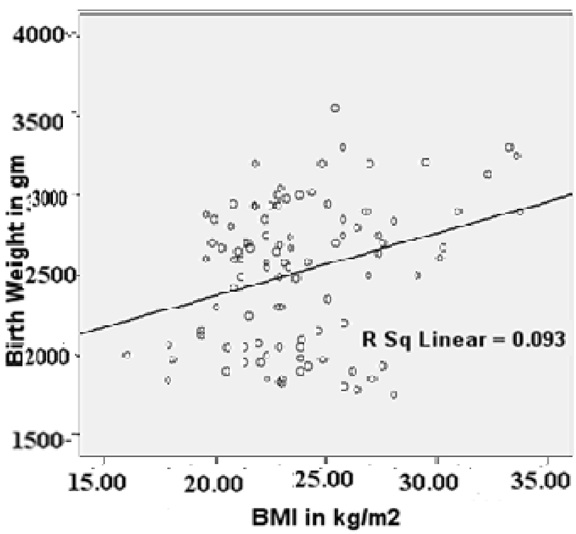

Fig. 4: Correlation between birth weight and BMI

DISCUSSION

Maternal nutritional status and anemia have a direct effect on birth weight of a newborn and birth weight is an important factor for growth and survival of the baby. The finding of different studies has shown that mothers with poor nutritional status and anemia have increased the risk of having low birth weight babies [27-36]. The result of the current study is compatible with those finding that the birth weight of newborns was lower if their mothers had lower levels of hemoglobin and BMI (Table 5 and Table 6). Studies in Bangladesh [32-34] revealed an association of birth weight with various socio-economic factors. Though not statistically significant, this study also revealed that young mothers (age ≤20 years), mothers with less education and mothers who lived in *katcha* house gave birth to LBW babies (<2500gr). However, this study revealed an association between the increased birth weight of the babies and mother having no anemia and overweight. Correlation analysis also revealed a significant positive linear relationship between birth weight and maternal BMI (r=0.391; p=.002) and hemoglobin level (r=.333; p=.010) of the arsenic non-exposed mothers. On the other hand, no such significant relationships of maternal hemoglobin level and BMI with the birth weight of the babies born to arsenic-exposed mothers was found (Table 7). Thus, indicates that maternal BMI and hemoglobin level might have a diminished influence on the birth weight of the babies born to the arsenic-exposed mother.

Previous studies [23, 37-39] in Bangladesh reported that mothers having exposure to arsenic through drinking water had increased risk of having LBW babies. The result of the current study is also consistent with this finding. It was found that mothers with high arsenic in urine (≥381.38μg/L) were likely to have a lower birth weight of the babies. Further, this study revealed that in arsenic-exposed mothers, maternal urine arsenic concentration had a significantly strong negative linear relationship with birth weight (r=-.619; p=.000); but in non-exposed mothers, the association was mild and not statistically significant. After controlling for maternal BMI and hemoglobin level separately and together in arsenic-exposed mothers, almost a strong (60%, 58% and 59% respectively) significant negative relationship between arsenic concentration in maternal urine and birth weight of the babies was found (Table-8). On the contrary, no significant relationships were detected in non-exposed mothers. This indicates that arsenic exposure of mother could have a negative impact on the birth weight of the babies. And the influence was more pronounced in the case of arsenic-exposed mothers than the mothers on the whole.

Several studies [37, 40-45] have revealed the increased risk of adverse pregnancy outcomes as well as LBW due to chronic exposure to drinking arsenic contaminated water. Huyck [38] reported an association between decreased birth weight and arsenic concentration in maternal nail and hair measured in early pregnancy, and that birth weight was not associated with either maternal hair and nail arsenic or infants' hair and nail arsenic measured at birth. Arsenic in hair and nail is an indication of past exposure or an external contamination [46-48]. The arsenic content of maternal hair and nail at childbirth could be considered to be representative of the exposure throughout pregnancy but could be lower than that in early pregnancy if the mother had attained an arsenic-safe water source subsequent to initial sample collection. High urine arsenic of the exposed mother (≥100µg/L) in the current study was an indication that they had current exposure [48-50], in addition, they had a history of drinking water from the same tube well for the last two years. So it was less likely that the mothers had varied exposure throughout their pregnancy. It was found that the urine arsenic concentration measured at birth was associated with the birth weight of the babies. On the other hand, BMI and hemoglobin levels of mothers having no exposure to arsenic were found to have a significantly positive effect on birth weight of the newborn. But neither the BMI nor the hemoglobin levels of mothers having arsenic exposure were found to have a significant positive effect on birth weight. Therefore, it is likely that arsenic exposure during pregnancy negatively affects birth weight and also offsets the positive effects maternal BMI and hemoglobin level on the birth weight of the newborn. However, there remains a need for further study to establish relationships of birth weight with exposure to arsenic through drinking water; and arsenic in hair, nail and urine.

CONCLUSION

Maternal exposure to arsenic through drinking water could result in significant decrease of birth weight of the newborn, higher the exposure greater the risk. On the other hand, despite having favorable maternal BMI and hemoglobin level increasing maternal arsenic exposure could negatively affect the birth weight of the newborn.

ETHICAL ISSUES

Ethical issues including plagiarism have been observed by the authors

CONFLICT OF INTEREST

The author(s) declare that they have no competing interest

AUTHORS' CONTRIBUTION

All authors participated in all stages of the study and contributed equally**.**

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