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Original Research Article

Diabetes mellitus among arsenic exposed and non-exposed young adults in Bangladesh

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ABSTRACT

Background: Studies in different countries including Bangladesh have found association with arsenic exposure and diabetes mellitus. However, the occurrence of diabetes mellitus amongst the arsenic exposed young adults, remains to be elaborately explored. This study was carried out among the arsenic exposed young adults to assess their glycaemic status.
Methods: This was a cross sectional comparative study carried out among the arsenic exposed and non-exposed young adults aged 30 to 39 years.
Results: Among the total 1546 respondents, arsenic exposed respondents were 1043(67.5%) and non-exposed respondents were 503 (32.5%). Of the arsenic exposed respondents 494 (47.4%) were suffering from arsenicosis. The arsenic exposed respondents were found to suffer more from DM (5.6%) and IGT (23.0%) compared to those of non-arsenic exposed respondents and the difference was highly significant ($\chi2$= 30.470; p=0.000). While comparing DM and IGT between arsenicosis and non-arsenicosis respondents, significantly ($\chi2$=12.989; p=0.002) a higher proportion of the arsenicosis respondents were found to suffer from DM (7.9%) and IGT (24.9%). Multinomial regression analysis showed, DM and IGT were 3.6 times and 2.5 times more likely to develop among the young adults having arsenicosis compared to those of non-exposed young adults.
Conclusions: The study revealed that the arsenic exposed population is at high risk of developing diabetes and IGT in their early adult hood. Among the arsenicosis young adults the situation is more threatening; the prevalence is more than twice compared to that of arsenic non-exposed young adults.

Keywords: Arsenic, Arsenicosis, Arsenic toxicity, Bangladesh, Diabetes, DM, Glycaemic status, IGT

INTRODUCTION

Chronic exposure to arsenic through groundwater and its consequent health effects is a major public health problem in Bangladesh. About 50 million people are at risk of exposure to arsenic at a level of more than Bangladesh standard (0.05mg/L). Arsenic contamination of tube well water has been reported from 62 out of 64 districts of Bangladesh. Until 2012, so far, 65,910 arsenicosis patients have been identified by Directorate General of Health Services of Bangladesh.[1,2] Chronic arsenic exposure has been reported to be linked with many non-communicable diseases including cancers.[3] Several studies have reported an association with arsenic exposure and diabetes mellitus.[3-8] Association of arsenic exposure with non-communicable diseases including

diabetes has been revealed in studies carried out on arsenic exposed population in Bangladesh.[9]

Worldwide prevalence of diabetes mellitus is increasing in alarming way and is becoming a top cause of death. Every six seconds a person dies due to diabetes and it is projected that by 2030 diabetes will be the 7th leading cause of death.[10,11] It has been also predicted that the global prevalence of diabetes mellitus will rise to 10% in 2030 from 8% in 2011. International diabetes Federation (IDF) in its 6th Diabetes Atlas reported that an estimated 382 million people were living with diabetes mellitus, while the 7th Diabetes Atlas estimated 415 million have diabetes. Most of the diabetic patients live in Asia. China and India are said to be the home of diabetes, 90.0 million (9%) people in china and 61.3 million (8%) people in India were found to be suffering from diabetes mellitus.[11,12] However, in Bangladesh 8.4 million (10%) people were found to be suffering from diabetes mellitus in 2011 while fifteen years back (1995) the prevalence of diabetes (4%) was 2.5 times less than that in 2011. As predicted, in 2030 the prevalence will be raised to 13% which will be more than 3 times of the prevalence in 1995.[12,13] Studies carried out in Bangladesh found that diabetes mellitus was more common among older people.[13,14] Further, a higher proportion of diabetes mellitus was found among those from urban areas, among the population of high socioeconomic status, and among those who were obese or overweight. The risk of prediabetes was found to be increased with age. Compared with the younger group aged 35 to 39 years, the risk of prediabetes was 1.64 times higher in individuals aged 60 to 69 years.[14]

In different studies, higher prevalence of diabetes mellitus was found amongst the arsenic exposed population compared to that of an arsenic non-exposed population.[4-7] A study conducted in Bangladesh also revealed such association amongst the arsenic exposed population having keratosis due to chronic arsenic toxicity.[9] Arsenicosis, the illness due to chronic arsenic toxicity is reported to occur more commonly amongst the young adults.[15,16] Therefore, there might be an increased risk of diabetes mellitus among the arsenic exposed young adults. This study tried to find out the extent of occurrence of diabetes mellitus among arsenic exposed young adults in Bangladesh.

METHODS

This was a cross sectional comparative study carried out to assess the glycaemic status among the arsenic exposed and non-arsenic exposed young adults. The young adults aged 30 to 39 years and lived in the study area at least three years were the study population. The rural area where arsenic contents in the tube well water was more than 0.05mg/L was selected as arsenic exposed and the area where arsenic contents in all the tube wells water was less than 0.05mg/L was selected as arsenic non-exposed. Sample population from arsenic exposed area was categorized into arsenicosis and non-arsenicosis respondents and who were from the non-exposed area was categorized as non-exposed respondents. For data collection in both exposed and non-exposed area medical camps were organized. The sample population listed on the previous day came into the camp for examination of fasting blood sugar (FBS) and blood sugar after 75mg of glucose (2HABF) intake as well as for face to face interview and other measurements related to this study. For every respondent, fingertip blood samples were taken with precautions for both FBS and blood sugar 2HABF. The blood samples were examined for blood glucose by the BIRDEM (Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders) recommended Glucometer. For any doubtful case, second time blood examination was done then and then. If variations found more than 0.5dl/L average of the reading of two examinations was considered, if not the highest one was considered for the study. In between two blood examinations, the respondents were interviewed face to face and necessary physical examination including the recording of height and weight was carried out. During the participant selection water sample was collected from the respondent's water source for estimation of arsenic. The daily dose of arsenic of a respondent was estimated by multiplying arsenic concentration of particular tube well water in ppb and daily average water intake in liter. BMI was grouped as underweight (<18.5), normal (18.5-25.0) and overweight and obese (>25.0). Men and women with waist-hip ratios >0.90 and >0.85 respectively were classed as having central obesity. The glycaemic status was categorized as diabetes mellitus (DM), prediabetes (IGT} and normal glycaemic status on the basis of WHO criteria.

Necessary approval for this study was taken from the Institutional Ethical Review Committee. During listing of the sample population, on the day before data collection, the respondents' were briefed about the purpose of the study and data collection procedure. They were requested not to eat or drink anything after the night meal and to break the fasting when instructed at the camp. They were also informed that their participation is voluntary and they can withdraw their participation from the study anytime and there is no penalty for such withdrawal. They were ensured that their personal identity will not be disclosed and confidentiality will be maintained.

RESULTS

Among 1546 respondents, 67.5% (1043) were arsenic exposed and remaining 503 (32.5%) were non-arsenic exposed. The mean age of the respondents was 34.3 (±2.83) years and there was no significant difference of age between exposed and non-exposed respondents. Of the total respondents, males (38.0%) were less than the females (62.0%). Majority (60.4%) of the respondents were housewives, others were farmers or laborers (26.3%) and they had an average annual income of Taka 91361 (±45591). Tobacco chewing was found to be

significantly high ($\chi 2$=41.276; p<0.001) among the non exposed respondents (29.0%) compared to that of exposed respondents. Among the arsenic exposed respondents, the respondents with arsenicosis were 47.4% and non-arsenicosis respondents were 52.6%. The arsenicosis and non-arsenicosis respondents were significantly different (t=-3.008; p=0.003) in mean age, which was 33.9±2.72 years and 34.5±2.76 years respectively. However, other characteristics between arsenicosis and non arsenicosis respondents were not significantly different (Table 1 and Table 2).

Regarding arsenic exposure of the exposed respondents, it was found that the respondents having arsenicosis, collected drinking water from tube wells yielding water with higher levels of arsenic (274.27ppb) and the range was 123.33-490.00ppb. Similarly, the daily total arsenic intake was also found high (936.57ppb) among them and the range was 383.57-1866.90ppb. The difference of arsenic exposure between respondents with arsenicosis and without arsenicosis in-terms of arsenic concentration in tube well water and daily intake of arsenic through drinking water was found to be statistically significant (t=7.739; p=0.000 and t=5.987; p=0.000 respectively) (Table 2).

Table 1: Characteristics of the arsenic exposed and non-exposed respondents.

Respondents' characteristics		Status of arsenic exposure N=1546			Statistical test
		Exposed n (%)	Non-Exposed n (%)	Total n (%)	
Over all		1043 (67.5)	503 (32.5)	1516 (100)	
Age (years)	Upto 34	502 (48.1)	231 (45.9)	733 (47.4)	χ^2=0.662; p=0.416
	35 & above	541(51.9)	272 (54.1)	813 (52.6)	
	Mean±SD	34.3±2.75	34.2±3.00	34.3±2.83	t=0.088; p=0.93
Sex	Male	412 (70.1)	176 (29.9)	588 (38.0)	χ^2=2.930; p=0.087
	Female	631 (66.9)	327 (34.1)	958 (62.0)	
Annual income (Taka)	Mean±SD	91641±44088	90779±48601	91361±45591	t=0.085; p=0.72
Occupation	House wife	617 (58.2)	317 (63.0)	934 (60.4)	χ^2=4.647; p=0.098
	Business/Service	134 (12.8)	71 (14.1)	205 (13.3)	
	Labour/farmer	292 (28.0)	115 (22.9)	407 (26.3)	
Tobacco consumption	No Tobacco	692 (66.4)	269 (53.5)	961 (62.2)	χ^2=41.276; p<0.001
	Chewing	160 (15.3)	146 (29.0)	306 (19.8)	
	Smoking	191 (18.3)	88 (17.5)	279 (18.0)	

Table 2: Distribution of the arsenic exposed respondents by different characteristics and arsenic exposure.

Respondents' characteristics		Arsenic exposed respondents (N=1043)		Statistical test
		With arsenicosis n (%)	Without arsenicosis n (%)	
Over all		494 (47.4)	549 (52.6)	
Age (years)	Upto 34	241(48.1)	261 (51.9)	χ^2= 0.824; p=0.662
	35 & above	253(46.8)	288 (52.3)	
	Mean±SD	33.9 ±2.720	34.5±2.762	t=-3.008; p=0.003
Sex	Male	196 (47.6)	216 (52.4)	χ^2=0.012; p=0.913
	Female	298 (47.2)	333 (52.8)	
Annual income (Taka)	Mean±SD	91124±45444	92106±42868	t=0.359; p=0.719
Occupation	House wife	290 (58.7)	327(59.6)	χ^2=5.202;p=0.074
	Business/Service	75 (15.2)	59 (10.7)	
	Labour/farmer	129 (26.1)	163 (29.7)	
Tobacco consumption	No Tobacco	326 (66.0)	366 (66.7)	χ^2=.644;p=0.725
	Chewing	73 (14.8)	87 (15.8)	
	Smoking	95 (19.2)	96 (17.5)	
Arsenic in tube well water (ppb)	Mean±SD	274.27±63.37	245.26±57.67	t=7.739; p=0.000
	Min-Maximum	123.33-490.00	109.60-448.03	
Daily dose of arsenic (ppb)	Mean±SD	936.57±271.24	839.60±251.80	t=5.987 p=0.000
	Min-Maximum	383.57-1866.9	340.86-1706.88	

Table 3: Distribution of respondents' characteristics by their glycaemic status.

Respondents' characteristics		Glycaemic status				Statistics
		Normal n (%)	IGT n (%)	DM n (%)	Total n (%)	
Over all		1169 (75.6)	304 (19.7)	73 (4.7)	1546 (100)	
Age (years)	Upto 34	556 (75.9)	145(19.8)	32 (4.4)	733 (47.4)	*χ^2= 0.395; p=0.821
	35 & above	613 (75.4)	159 (19.6)	41 (5.0)	813 (52.6)	
	Mean±Sd	34.2 ±2.864	34.3±2.825	34.5±2.381	34.2±2.835	P=0.669
Sex	Male	461 (78.4)	101 (17.2)	26 (4.3)	588 (38.0)	*χ^2= 4.140; p=0.126
	Female	708 (73.9)	203 (21.2)	47 (4.9)	958 (62.0)	
Annual income (Taka)	Mean	91266	92171	89493	91361	*p=0.894
	Std Dev	45982	42598	51575	45591	
Occupation	House wife	689 (73.8)	198 (21.2)	47 (5.0)	934(60.4)	*χ^2= 5.490; p=0.241
	Business/Service	164 (80.0)	31 (15.1)	10 (4.9)	205 (13.3)	
	Labour/farmer	316 (77.6)	75 (18.4)	16 (3.9)	407 (26.3)	
Tobacco consumption	No Tobacco	727 (62.2)	188 (61.8)	46 (63.0)	961(62.2)	†χ^2= .359; p=0.966
	Chewing	234 (20.0)	58 (19.1)	14 (19.2)	306 (19.8)	
	Smoking	208 (17.8)	58 (19.1)	13 (17.8)	279 (18.0)	
BMI status	Under weight	500 (42.8)	120 (39.5)	23(31.5)	643(41.6)	χ^2= 13.714; p=0.008
	Normal	590 (50.5)	167 (54.9)	38 (52.0)	795 (51.4)	
	Over weight & obese	79 (6.7)	17 (5.6)	12(16.5)	108(7.0)	
Waist-hip ratio	Central obese	331 (28.3)	89 (29.3)	21 (28.8)	441 (28.5)	χ^2= 0.112; p=0.946
	Non-obese	838 (71.7)	215 (70.7)	52 (71.2)	1105 (71.5)	

IGT- Impaired glucose tolerance (Pre-diabetes); DM- Diabetes mellitus.

Table 3 shows the glycaemic status and different characteristics of the respondents. It was found that among the total 1546 respondents, 4.7% were found to suffer from diabetes, 19.7% were found to have prediabetes and three-fourth (75.6%) of them had a normal glycaemic state. Except the BMI, other characteristics among the respondents with diabetes mellitus (DM), prediabetes (IGT) and normal glycaemic state were not statistically dissimilar. However, among the respondents having diabetes, overweight and obesity (16.5%) was found significantly high (χ2=13.714; p=0.008). Regarding glycaemic status in relation to the arsenic exposure of the respondents, it was found that both DM and IGT were found to be significantly (χ2=30.470; p=0.000) high among the respondents with arsenic exposure (5.6% and 23.0% respectively) compared to those of non-arsenic exposed respondents. Moreover, the proportion of DM (7.9%) and IGT (24.9%) were found significantly increased (χ2=12.989; p=0.002) among the respondents having arsenicosis while comparing with the respondents having arsenic exposure but no arsenicosis. As regards to arsenic exposure, a higher concentration of arsenic in tube well water (266.27± 55.72ppb) and a higher daily dose of arsenic (907.90±244.07 ppb) intake was found among the respondents having diabetes, but the difference was not statistically significant with those of others (Table 4).

Table 4: Distribution respondents by glycaemic status (DM and IGT) and arsenic exposure.

Arsenic exposure		Glycaemic status			
		Normal	IGT	DM	Statistics
Arsenic exposed	Yes	745 (71.4%)	240 (23.0%)	58 (5.6%)	χ^2=30.470; p=0.000
	No	424 (84.3%)	64 (12.7%)	15 (3.0%)	
Arsenicosis	Yes	332 (67.2%)	123 (24.9%)	39 (7.9%)	χ^2=12.989; p=0.002
	No	413 (75.2%)	117 (21.3%)	19 (3.5%)	
Arsenic in TW water	Mean±SD	256.75±62.10	264.24±63.41	266.27±55.72	F=1.745, p=0.175
	Mini-Maximum	109.6-445.0	161.38-451.03	158.0-490.0	
Daily dose of Arsenic	Mean±SD	882.26±266.87	890.25±266.98	907.90±244.07	F=-300, p=0.741
	Mini-Maximum	340.86-1695.45	501.89-1718.43	575.82-1866.9	

Table 5 shows blood sugar levels by arsenic exposure and arsenicosis. Average FBS levels (4.90mmol/L) and blood sugar levels 2HABF (7.52 mmol/L) were significantly (t=11.158; p<001 and t=5.187; p<001 respectively) high among the arsenic exposed respondents compared to those of non-exposed respondents. Similarly, average FBS (5.07 mmol/L) and blood sugar levels 2HABF (7.70 mmol/L) were also significantly high (t=3.773; p<001 and t=3.268; p<001 respectively) among the arsenicosis respondents in comparison to those of non-arsenicosis respondents.

Table 5: Blood sugar levels in by arsenic exposure and arsenicosis.

Status of the respondents		Mean blood sugar level (mmol/L) *FBS Mean±SD (Min-Maximum)	**2HABF Mean±SD (Min-Maximum)	Statistics
Arsenic exposure	Exposed	4.90±0.903 (3.2 -11.6)	7.52±1.810 (5.7-22.3)	*t=11.158; p≤0.001
	Non-exposed	4.35±0.768 (3.1-8.3)	7.05±1.518 (4.8-18.9)	**t=5.187; p≤0.001
Arsenicosis	Yes	5.02±0.955 (3.2 -11.6)	7.70±1.971 (5.7-22.3)	*t=3.738; p≤0.001
	No	4.80± 0.846 (3.2 -10.7)	7.33±1.634 (4.8 -19.0)	**t=3.268; p≤0.001

FBS= Fasting blood sugar; 2HABF= 2 hours after breakfast.

Table 6: Multinomial logistic regression analysis of DM and IGT in relation to possible confounders.

Dependent Variables[a]	Diabetes mellitus					Impaired glucose tolerance				
Independent Variables	B	Sig.	Exp (B)	95% Confidence Interval		B	Sig.	Exp (B)	95% Confidence Interval	
				Lower bound	Upper bound				Lower bound	Upper bound
Intercept	-5.118	0.001				-2.227	0.007			
Age	0.037	0.413	1.038	0.950	1.134	0.011	0.632	1.011	0.966	1.059
Arsenicosis	1.294	**0.000**	3.646	1.945	6.836	.928	**0.000**	2.530	1.798	3.559
Non-Arsenicosis (exposed)	0.271	0.451	1.311	0.648	2.651	0.652	0.**000**	1.920	1.366	2.699
Non-exposure[b]	0	.	.	.	.	0				.
Tobacco chewing	0.094	0.778	1.098	0.573	2.104	0.005	0.975	1.005	.711	1.421
Smoker	0.138	0.720	1.148	0.541	2.435	0.426	**0.044**	1.531	1.012	2.316
Non-smoker[b]	0	.	.	.	.	0	.	.	.	.
Non-obese (WHR)	0.173	0.552	1.189	0.673	2.099	-0.075	0.621	0.928	0.690	1.248
Obese (WHR)[b]	0	.	.	.	.	0	.	.	.	.
Obese (BMI)	1.411	**0.001**	3.101	1.837	9.152	-0.103	0.730	0.902	0.502	1.621
Normal Wt.(BMI)	0.404	0.143	1.497	0.872	2.571	0.168	0.221	1.183	0.904	1.548
Under Wt (BMI)[b]	0	.	.	.	.	0	.	.	.	.
Male	-0.169	0.588	0.845	0.459	1.555	-0.495	**0.005**	0.610	0.432	0.860
Female[b]	0	.	.	.	.	0	.	.	.	.

A: The reference category is: Normal Glycaemic Status; b : This parameter is set to zero because it is redundant.

Multinomial logistic regression was used (Table 6) to explain the relationship between glycaemic status and arsenic exposed and non-exposed and other predictors amongst the respondents. It was found that arsenicosis and overweight and obesity had a statistically significant (p≤0.001) role in differentiating the occurrence of DM from the normal glycaemic status. On the other hand, arsenic exposed respondents with arsenicosis (p<0.001) and without arsenicosis (p<0.001), smokers (p=0.044) and males (p=0.005) were found to have a significant contributing role in differentiating the prevalence of IGT from normal glycaemic status. The analysis revealed that the arsenicosis patients were 3.65 times more likely to develop diabetes compared to that of non-arsenic exposed respondents. Respondents having overweight or obese were 3.1 times more likely to develop diabetes compared to that of the underweight respondents. Regarding IGT both arsenicosis and non-arsenicosis (but exposed to

arsenic) respondents were 2.53 times and almost 2 times respectively more likely to have IGT in comparison to those of non-arsenic exposed respondents. Further, it was found that the smokers were about 1.5 times more likely to develop IGT compared to that of non-smoking respondents. However, the male respondents were found 40% less likely to develop IGT in comparison to that of female respondents.

Hierarchical multiple regression was used (Table 7) to assess the ability of arsenicosis status and arsenic intake through drinking water to explain the variance of capillary blood glucose level in fasting condition and 2 hours after intake of 75 mg glucose by the arsenic exposed respondents. For controlling the influence, age and sex of the respondents were included into the model. In the first block, only sex was found to be significantly contributed in the variations of capillary blood glucose level and it was found that every unit increase in female, 0.130 mmol/L decreases in FBS level of male respondents. After controlling the influence of both age and sex, arsenicosis respondents found to have significantly high capillary blood glucose levels of both in fasting condition ($p<0.001$) and 2 hours after glucose intake ($p=0.005$). FBS was found to increase by 0.210mmol/l for every unit increase in the arsenicosis respondents. Similarly, blood sugar 2HABF was also found to increase by 0.328 mmol/L with every unit increase in arsenicosis respondents. Regarding the model consisted of a daily dose of arsenic intake and arsenicosis after controlling the influence of age and sex, it was found that arsenicosis respondents significantly able to predict the FBS ($p<0.001$) and blood glucose 2HABF ($p=.004$). With every unit increase in arsenicosis respondents, FBS expected to be increased by 0.212mmol/L and blood glucose 2HABF expected to be increased by 0.333 mmol/L. Amongst the predictors of FBS level in both the blocks (2a and 2b) arsenicosis had the largest impact, the Beta coefficients were 0.116 and 0.117 respectively. Similarly, among the predictors of blood glucose 2HABF in 2a blocks, arsenicosis also had the largest impact (Beta coefficients was 0.090).

Table 7: Linear logistic regression analysis of DM and IGT in relation to arsenicosis status, age, gender and arsenic exposure.

Dependent variables	Fasting glucose level					After 2 hours of glucose intake				
Independent Variables (Model)	Unstandardized Coefficients		tandardized Coefficients	T	Sig.	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta			B	Std. Error	Beta		
1. (Constant)	4.656	0.351		13.281	0.000	6.836	0.704		9.709	0.000
Gender	-0.130	0.057	-0.070	-2.272	**0.023**	-0.002	0.115	0.000	-0.016	0.987
Age in years	0.009	0.010	0.029	0.927	0.354	0 .020	0.020	0.031	0.990	0.322
2a. (Constant)	4.398	0.370		11.891	0.000	6.065	0.743		8.163	0.000
Gender	-0.121	0.062	-0.066	-1.963	**0.049**	0.086	0.125	0.023	0.689	0.491
Age in years	0.013	0.010	0.039	1.255	0.210	0.024	0.020	0.036	1.155	0.248
As in TW (mg/L)	0.151	0.505	0.010	0.299	0.765	1.723	1.014	0.059	1.698	0.090
Arsenicosis	0.210	0.058	0.116	3.631	**0.000**	0.328	0.116	0.090	2.821	**0.005**
2b. (Constant)	4.441	0.375		11.770	0.000	6.039	0.753		8.020	0.000
Gender	-0.121	0.077	-0.065	-1.574	0.116	0.165	0.154	0.045	1.069	0.157
Age in years	0.013	0.010	0.039	1.269	0.205	0.024	0.020	0.037	1.176	0.844
As daily dose (mg/L)	0.023	0.114	0.007	0.158	0.874	0.461	0.289	0.092	1.592	0.112
Arsenicosis	0.212	0.058	0.117	3.682	**0.000**	0.333	0.116	0.068	2.880	**0.004**

DISCUSSION

Both animal and human studies revealed that arsenic is diabetogenic. But its diabetogenic mechanism is yet unclear. [4-6,17,18] Studies conducted in different countries and also in Bangladesh revealed an association with arsenic exposure and diabetes.[4-9] According to the recent profile of Bangladesh International Diabetes Federation (BIDF), the prevalence of diabetes in the age group 30 to34 years was 4.5% and in the age group 35 to 39 years was 5.0%, while in the age group 60 to 64 years the prevalence (10.2%) was more than double.[19] The current study revealed a similar prevalence of diabetes among the age group 30 to 34 years (4.4%) and 35 to 39 years (5.0%). But while comparing the prevalence of diabetes with arsenic exposed and non-exposed respondents, the

prevalence was found significantly high (p=0.000) among the arsenic exposed population (5.6%). Moreover, significantly (p=0.002) an increased prevalence (7.9%) of diabetes was found amongst the arsenicosis respondents in comparison to that of non-arsenicosis, which was more than 2.5 times of the prevalence of non-arsenic exposed (3.0%) and non-arsenicosis respondents (3.5%). A study conducted in Cambodia among arsenic exposed population also found a higher proportion of diabetes (11.5% versus 7.3%) among the arsenicosis patients compared to that in non-arsenicosis participants[20]. Regarding IGT, again the arsenic exposed respondents were found to have a higher prevalence (23.0%) compared to that of non-exposed respondents (12.7%) and was highly significant (p=0.000). However, among the arsenicosis respondents, a more high prevalence of IGT (24.9%) was found compared to that of non-arsenicosis respondents (p=0.002). IGT is a risk factor for diabetes, the nationwide survey in Bangladesh revealed 23% of the population was suffering from IGT and the prevalence was more in the elderly population [14]. But in this study, the prevalence of IGT was found more than the national survey in the young adults with arsenicosis (24.9%). Thus, results revealed an indication that there might be increased occurrence of diabetes among the young adults in arsenic contaminated areas of Bangladesh.

Studies conducted in different countries and in Bangladesh have reported an association between low to moderate dose of arsenic exposure and diabetes.[21-25] Data available so far demonstrates a weak to high association between arsenic in drinking water (≥150 ppb) and diabetes.[26] However, a study conducted in Bangladesh did not show any association between diabetes and arsenic when the concentration of arsenic was less than 300 ppb in water.[27] In the current study significant association could not be found between the lower dose of arsenic exposure and DM and IGT amongst the arsenic exposed young adults.

But with a moderate exposure to arsenic in terms of arsenic concentration in tube well water and a daily dose of arsenic a high proportion of DM and IGT was found amongst the young adults. The minimum concentration of arsenic in the contaminated tube well water at which DM and IGT were found to occur were 158 ppb and 161ppb respectively and the minimum daily dose (estimated) was 575.82 ppb and 501.89 ppb respectively. On the contrary, among the arsenic exposed respondents having normal glycaemic status, the exposure to arsenic in-terms of minimum concentration of arsenic in tube well water and a daily dose of arsenic was comparatively very low.

However, this study revealed a significant association between the FBS level and blood sugar 2HABF with arsenic exposure through drinking water. It was found that among the arsenic exposed participants both FBS (4.90 mmol/L) and blood sugar 2HABF (7.52 mmol/L) on an average were significantly (p<0.001) high compared to those of non-arsenic exposed participants. In addition, significantly a higher average blood glucose levels (5.02 mmol/L and 7.70 mmol/L respectively) was found among the arsenicosis participants in comparison to those of non-arsenicosis participants (p<0.001). By logistic linear regression analysis, after removing the effect of possible confounders, though not statistically significant but a positive effect of arsenic intake was found on blood sugar level.

Overweight and obese is a known risk factor for diabetes and prediabetes. In this study among the young adults, overweight and obese was only 7.0%. Yet, significantly (p=0.008) a higher proportion of the diabetic participants was found to have overweight and obese (16.5%) compared to that of normal glycaemic status (6.7%). Further, the multinomial logistic regression analysis showed that after adjustment of the possible confounder's overweight and obese was significantly and positively associated with the occurrence of diabetes. In the nationwide survey both diabetes and prediabetes were found more likely (1.93 and 2.05 times respectively) to develop amongst over weight and obese compared to that of normal weight.[14] In other studies conducted in Bangladesh, diabetes was found to be 3.77 and 1.5 times more likely to develop amongst overweight and obese.[28,29] This study also revealed that diabetes was more likely (3.1 times) to develop amongst overweight and obese compared to that of underweight young adults. However, in the current study in regards to Waist-Hip ratio, no significant difference of central obese was found between DM, IGT and normal glycaemic status.

The socio-demographic factors which were included in this study are known risk factors for glycaemic status but none of them except gender was found to be significantly associated with diabetes and pre-diabetes (Table-2). Multinomial logistic analysis of this study showed that males were significantly less (40%) likely to develop prediabetes compared to that of the females. The nationwide survey of Bangladesh revealed similar findings that males were less likely to develop prediabetes (0.84 times).[14] A previous study conducted in rural areas of Bangladesh also revealed similar findings in relation to males.[28] But, a recent study conducted in Bangladesh revealed that males were more (1.5 times) likely to develop diabetes.[29] Further, a hospital-based study in Bangladesh also revealed males (1.39 times) were more likely to develop diabetes compared to that of the females.

This was explained as that in male dominant society females get less opportunity to attend a doctor or hospital and for which the proportion of males (56%) having diabetes attended the hospital was more than females.[30] As in the current study examination of participants were carried out in medical camps arranged in the vicinity of their residence, females participation was by far greater than that by males. And it was likely that detection of

higher numbers of diabetes and prediabetes could stem to higher female participation in the study.

Smoking is an important known risk factor for NCDs including diabetes. Compared with non-smokers, smokers were reported to be more likely to develop DM and IGT.[31,32] A study conducted among the rural population also found diabetes 2.0 times more likely to develop among the past and current smokers compared to that of nonsmokers.[22] But in this study, such relationship of smokers particularly with the occurrence of diabetes could not be found. The multinomial logistic analysis showed a significant (p=0.044) positive effect of smokers on IGT only.

Regarding arsenic exposure and development of diabetes, after adjustment of the possible confounders, multinomial regression analysis showed that amongst the young adults who were suffering from arsenicosis, both DM and IGT were more (3.65 times and 2.53 times respectively) likely to develop compared to that of arsenic non-exposed young adults. Further, it was found that arsenic exposed young adults (not suffering from arsenicosis), prediabetes was also more (1.92 times) likely to develop compared to that of non-arsenic exposed young adults. Thus, the current study revealed a strong association between arsenic exposure and diabetes and prediabetes among the young adults.

Arsenicosis, the illness due to chronic arsenic toxicity, is more common among the young adults of arsenic exposed population in Bangladesh.[16,17] On the other hand, it is known that in young adults, the prevalence of diabetes and prediabetes is low compared to that of elderly people. But in this study arsenicosis was found to be a high risk factor for diabetes and prediabetes development. Thus, in Bangladesh, the arsenic exposure through drinking water and arsenicosis could be the influencing factor for the increased prevalence of diabetes especially among the young adults. Therefore, particularly in the arsenic contaminated areas of Bangladesh, diabetes screening program could be expanded and which can be done through integration with community clinic activities.

CONCLUSION

The study revealed that the arsenic exposed population is at high risk of developing diabetes and prediabetes in their early adult hood compared to those of non-arsenic exposed population. As found in this study, among the arsenicosis respondents the prevalence of diabetes was more than twice compared to that of arsenic non-exposed young adults. Therefore, it could be said that the situation is more threatening to them who are suffering from arsenicosis.

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