Drinking of Arsenic Contaminated Water and Age at Menarche: An Association Study in North 24 Parganas of West Bengal

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ABSTRACT: Chronic exposure to arsenic contamination through drinking water is a major environmental threat of West Bengal and has been associated with skin lesion, cancer of lungs, bladder, liver and kidney. The present study investigates the effect of this environmental hazard on age at menarche in North 24 Parganas district, one of the worst affected district of West Bengal. Mean menarcheal age (13.6 ± 0.48 years) is higher among women belonging to arsenic affected area by birth, than control population (11.1 ± 0.66 years) who came from non arsenic effected area after marriage. The differences in menarcheal age between these two groups are found to be statistically significant ($p < 0.05$). The study concluded that arsenic exposure might be associated with delayed menarcheal age.

INTRODUCTION

Exposure to arsenic (As) through drinking water is a major worldwide public health problem. It is established by several authors that chronic exposure to arsenic is associated with cancer of skin, lungs, bones, kidneys, liver, bladder etc. Beside these, age at menarche also affect due to intake of arsenic contaminated water for long time. Age at menarche is very commonly used and an important part of adolescent girl's growth and development process. There are so many factors affecting this natural event such as genetics, birth weight, nutrition, rural urban settings and so on.

In India one of the most arsenic affected region is the Ganges Delta plain and the state of West Bengal. Arsenic contamination through drinking water is a major public threat of 12 districts of this state. Among them the situation is worst in North 24 Parganas. It is evident from the study of Chowdhuar (Chowdhury *et al*., 2000) and Chakraborty (Chakraborty *et al.*, 2002, 2009) that problem is acute in the Holocene alluvium and deltaic underground water of the delta region of Bangladesh and of West Bengal, India. A large area of the Ganga, Meghna Bramhaputra Plain with an area 569,749 km^2 and population over 500 million might be at risk from ground water arsenic contamination (Chakraborty *et al* , 2004). And near about 100 million people living in this zone with arsenic above 0.05 mg/liter (Chowdhury *et al.*, 2000; Chakraborty *et al.*, 2002).

The lethal dose of arsenic ranges from 120 to 200 mg in adults and 2 mg/kg in children. Intake of drinking water having arsenic concentration beyond the permissible limit of 0.05 mg/lit has deleterious effects on human health viz. cardiovascular problem, gastrointestinal, hematological effects, hepatic effects, renal effects, neurological effects, dermal effects,

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carcinogenic effects etc (Elangovan *et al*., 2006). Aschengrau *et al.* ('89) found that higher spontaneous abortions among women exposed to arsenic (As) through drinking water. Spontaneous abortion and stillbirth were significantly higher in the arsenic (As) exposed group in Bangladesh and its reported by Ahmad *et al*. (2001), Milton *et al.* (2005), and Von Ehrenstein *et al.* (2006).

Inter-individual variation in arsenic methylation profile is commonly observed in exposed populations. Symptoms of chronic arsenic toxicity develop between 5 to 20 years. The time of onset depends on the concentration of arsenic in drinking water, volume of intake, health and nutritional status of the individuals. Good health and nutrition is very important to neutralize the arsenic toxicity in human body. It has been reported that in West Bengal, populations suffering from malnutrition have increased probability to arsenic toxicity (Guha Mazumder *et al*.,'98).

Few studies reported association between arsenic exposure and fetal losses and infant deaths and cognitive development and environmental studies indicate interaction with oestrogen. Arsenic also depletes body stores of iron, vitamin C and other essential nutrients leading to intrauterine growth retardation, decreased immune resistance and disabilities associated with malnutrition. So theoretically one possibility arises that the chronic revelation of arsenic contaminated water may affect the age at menarche as it has a definite correlation with malnutrition. Few studies (Sen and Das Chaudhuri, 2007; Sengupta, 2004) evaluated the association between arsenic exposure and age at menarche, and result showed that age at menarche of the adolescent girls delayed when exposed to arsenic. Keeping in mind the above said reviews, the present study intends to explore the association between arsenic exposure (exposed to arsenic contamination through ground water) and the age at menarche among the females of the 6 villages in Gaighata and Habra II block, North 24 Parganas District of West Bengal.

MATERIALS AND METHODS

Menarcheal age was collected in 2015-2016 by the recall method from 304 Bengali speaking Hindu participants (209 adult female and 95 adolescent girls) from arsenic affected villages in North 24 Parganas district of West Bengal, India, having long exposure with arsenic contaminated ground water. Data collected consist of 209 adult women including arsenic contaminated water consuming group (n=126), and arsenic free water consuming group (n=83). Data were compared with control population of same socio-economic group (n=83) those who migrated to the region after getting married and are from non affected area of same district after matching some conditions (education, monthly income, food habits, family size etc) and intake arsenic free (<0.05mg/l) drinking water from their infancy.

The study area is approximately 65 km away from Kolkata (capital of West Bengal) and quite convenient to reach by rail or road. Gaighata and Habra II blocks are of the 20 severely arsenic affected blocks, out of the 22 affected blocks in North 24 Parganas district, where groundwater contains arsenic above 0.05mg/l (Rahaman *et al*., 2003).

After getting Institutional Ethical Committee approval, verbal consents were obtained from all participants prior to the commencement of the study. Present age, age at menarche, migration history, source of drinking water, such kind of information were obtained by means of a questionnaire and using recall method. There was no missing data. The results were statistically analyzed using Microsoft excel and SPSS software (version 16). Statistical comparisons were carried out through the use of chi-square test (χ^2) and student's t-test.

RESULTS AND DISCUSSION

The age at menarche was collected from women and adolescent girl participants of studied area where arsenic level in drinking water is above 0.01 and 0.05 mg/l. All participants were from Bengali speaking Hindu population where the predominant occupation was agriculture. According to economic condition each group was divided into three categories like high income group (> ₹ 2000), medium income group (₹ 1000 – ₹ 2000) and low income group (< ₹ 1000). In respect of education, 67.4% of affected and 61.4% of non affected participants are literate. Table 1 shows that socio economic strata of studied participants specially women of studied area. The difference between two groups are non significant with respect to both education and economy ($p > 0.05$).

TABLE 1

Socio economic variables of studied participants

Category of women from	Education			Economy			
	Literate (n-136)	Illiterate (n=73)	*p* value	Lower > ₹1000)	Middle ₹1000 - 2000	Higher > ₹2000	*p* value
Arsenic affected area (n= 126)	85 (67.4)*	41 (32.5)	0.372	101 (80.1)	12 (9.5)	13 (10.3)	0.657
Non Arsenic affected area (n=83)	51 (61.4)	32 (38.5)		65 (77.1)	11 (10.8)	7 (7.2)	

Note: Not significant at p <0.05 * Figures in parenthesis indicate percentage

However, as evident from Table 2, most notable result is that the mean age at menarche of affected group was found to be higher (13.6 ± 0.48 years) than those belongs to non affected group (11.1 ± 0.66 years). To find out whether the differences are statistically significant or not, paired *t* test has been conducted. The results clearly suggested that the differences are statistically significant (t= -32.28525, df= 207, p <0.0001) at *p* <0.05.

TABLE 2

Mean menarcheal age of the participants of studied area

Types of water consumption	Mean age at menarche (in year)	SD	Range (in year)	*t* value	*p* value
Women consuming arsenic contaminated water (n= 126)	13.6	0.48	13-15	32.2852	<0.0001
Women consuming safe water (n=83)	11.1	0.66	9-12.5		

Note: Significant at *p* <0.05

Some studies opined that the arsenic toxicity in human body may reduce the essential nutrients which mainly help and control the intra uterine health of girls. Menarcheal age was collected from the field, others data like source of water intake, menarcheal age etc. also collected. Out of 300 children, only 95 girl child belongs to adolescence group (above 10 years). Table 3 depicts age distribution of studied adolescence girls. This age distribution table shows that only 21 girls are representing above 10 years old age-group and among them only one (4.76%) girl having menstruation. Maximum (27.3%) number of girls present in above 13 years old age-group and most (44.5%) of them having menstruation. Simultaneously only 5 numbers (100%) of girls represent above 15 years age-group and all attaining their menarche. The reason behind this delayed menarche may be the arsenic toxicity in the body. The data is too small to prove it as well as experimental and further study is needed.

TABLE 3

Age distribution of adolescence girl (N=95)

Present age of girls(in years)	Having menstruation	Not having menstruation	Total number of respondents
10 .01 to 11	1 (4.76%)	20 (95.24%)	21(22.1%)
11.01 to 12	4(23.5%)	13 (76.4%)	17 (17.8%)
12.01 to 13	5 (35.7%)	9 (64.3%)	14 (14.7%)
13.01 to 14	20 (76.9%)	6 (23.1%)	26 (27.3%)
14.01 to 15	10 (83.3%)	2 (16.7%)	12 (12.6%)
Above 15	5 (100%)	Nil (0%)	5 (5.26%)
Total	45 (47.4%)	50 (52.6%)	95

Mean menarcheal age among adolescent girl of arsenic affected area is demonstrated in Table 4. In this table girl having two categories one is consuming arsenic contaminated water that means tube well water and another one is consuming arsenic free that means mineral water or municipal supply water.

TABLE 4

Mean menarcheal age among adolescence girl (N=95) of studied area

Category	Girl who are having menstruation	Mean age at menarche	*t* value	*p* value
Girls consuming Arsenic contaminated water(n= 66)	27 (40.9)*	13 years ± 0.89	1.84	0.036†
Girls consuming Arsenic free water(n=29)	19 (65.5)	11.5 years ± 2.12		

* Indicate percentage; †Significant at p<0.05level

This table interestingly gives a picture of mean age at menarche among adolescence girls of studied area. Mean menarcheal age is higher among girls (13 years ± 0.89) those who are consuming arsenic contaminated water than girls (11.5 years ± 2.12) who consuming arsenic free water. Statistically the result is significant at $p<0.05$ level.

The mean menarcheal age obtained in the present study are in broad agreement with previous studies among Bengalee populations. According to Sengupta *et.al.,* the mean age at menarche was 12.23 years among Brahmin girls, 11.96 years among Kalita, 11.92 years among Kaibarta. Among Bangladeshi girls the mean age at menarche was 13.00 years (Chowdhury *et.al.,* 2000).

TABLE 5

Comparison with similar studies conducted in North 24 Parganas District, West Bengal

Number of people and place of study	Mean age at menarche (±SD)	Authors
175 girls from arsenic affected area of Ashoknagar and Basirhat of North 24 Parganas	14.04±1.05 years	Sengupta, 2004
280 arsenic affected Bengalee females from		
Kamdebkati	12.77±0.83 years	Sen and
Shimulpur	12.82±0.61 years	Das Chaudhuri, 2007
Raghabpur and	11.96±0.71 years	
Chandalhati of North 24 Parganas	12.44±0.81 years	
Present study, arsenic affected girls (n=126) at Gaighata and Habra II blocks of North 24 Parganas	13.6 ± 0.48 years	Arpita Jana & Subir Biswas,(*Present study*)

Studies on the effect of toxic elements and pollutants on the onset of menarcheal age are few in number. Axmon (2006) and Denham *et al* (2005) concluded that exposure to organochlorine pollutants and toxic elements has negative effects on age at menarche. In the last decade two studies on menarcheal age of arsenic affected areas of the North 24 Parganas were reported (Table 5). Among first of such types, Sengupta (2004) in a letter to editor reported that the mean age at menarche of arsenic affected group was found to be higher (14.04±1.05 years) than control group (13.28±0.97 years). Sen and Chaudhuri (2007) also conducted similar study (see Table 5) on four As affected villages of North 24 Parganas, and found statistically significant higher age at menarche among participants of three affected villages (12.77±0.83, 12.82±0.61, 12.44±0.81 years) compared to control (11.71±0.85 years). However, the results of fourth village (11.96±0.71 years) do not differ statistically from control one.

The result of the present study found that exposure to Arsenic through ground water can have an adverse effect on the age at menarche by delaying it. However, the effect of arsenic (As) on late menarcheal age required further studies which can eliminate other factors because of arsenic (As) contamination such as diet, nutrition, stress and so on.

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