PREVALENCE OF ARSENICOSIS AND ITS RELATION TO DRINKING WATER IN TITABOR BLOCK OF JORHAT DISTRICT, ASSAM, INDIA

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ABSTRACT

BACKGROUND

Human health effects due to chronic exposure of arsenic from drinking water is a major public health problem worldwide including India. In Assam, the arsenic level in groundwater of Titabor block of Jorhat district has been reported to be very high. The present study was carried out to find out health impact of arsenic exposure from drinking water on people living in Titabor.

The study was carried out to assess the prevalence of chronic arsenic toxicity (arsenicosis) in Titabor block of Jorhat district, Assam, and to determine the factors associated with chronic arsenic toxicity (arsenicosis) in relation to drinking water in the study population.

MATERIALS AND METHODS

Community-based cross-sectional study was carried out by selecting 30 clusters using PPS (probability proportional to size) method. Total of 780 individuals were studied and 30 water samples were tested.
Statistical Analysis- The data collected were analysed using Epi info version 7, Microsoft Excel and SPSS version 18 (trial version).

RESULTS

Prevalence of arsenicosis amongst the study population was found to be 0.38±0.019%. Currently, majority (49.2%) of study subjects consumed water supplied by PHE Department, while in past, majority (55%) of study subjects used pond water as drinking water. The mean concentration arsenic of water samples was 66.9 µg/L (SD 18.08).

CONCLUSION

The presence of high arsenic concentration in drinking water along with the presence of arsenicosis cases indicates the drinking water to be the determinant factor of arsenic exposure.

KEYWORDS

Arsenicosis, Keratosis, Melanosis.

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BACKGROUND

World Health Organization has defined arsenicosis as a chronic health condition arising from prolonged ingestion of arsenic above the safe dose for at least six months, usually manifested by characteristic skin lesions of melanosis and keratosis occurring alone or in combination with or without the involvement of internal organ.[1]

Human health effects due to chronic exposure of arsenic from drinking water is a major public health problem worldwide including India.[2] Arsenic was known to mankind since fourth century BC.[3] Arsenic is a metalloid and is twentieth most abundant element in earth's crust.[4] In ancient era, arsenic was used as a therapeutic agent by Greeks and Romans. Before the discovery of penicillin, arsenic compounds were the mainstay of treatment of syphilis.[5,6]

Arsenic is found in nature in both organic and inorganic form. The inorganic forms consisting mostly of two forms, arsenite (trivalent form) and arsenate (pentavalent form) of which trivalent arsenic is considered to be more toxic than pentavalent arsenic. Humans are exposed to arsenic primarily from air, food and water.[4,7] Organic forms are usually less toxic than the inorganic arsenic compounds.[5] Arsenic is used in industry to manufacture paints, fungicides, insecticides, pesticides, rodenticides, herbicides, wood preservatives, cotton desiccants, light emitting diodes, lasers and for many other purposes.[5,6]

Elevated arsenic level in drinking water is known to be the major cause of arsenic toxicity in the world.[4] Chronic arsenic toxicity in humans due to prolonged exposure is

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known as arsenicosis (WHO). The World Health Organization has recommended concentration of arsenic in drinking water 10 µg/L as an allowable range for human consumption[8] and Government of India has recommended maximum permissible limit in drinking water as 50 µg/L.[9]

Reports suggest arsenic contamination in water from more than 30 countries in the world.[4] Of these, the high concentration of arsenic in groundwater are reported from large areas of India, Bangladesh, Taiwan and Northern China. Other Asian countries affected are Lao PDR, Cambodia, Myanmar, Pakistan, Nepal, Thailand and Vietnam. Significant arsenic contamination of groundwater are also reported from Hungary, Mexico, USA, Chile and Argentina.[7,10,11]

Major affected regions of South-East Asia are the basin of the Ganga-Brahmaputra-Meghna rivers and the Mekong Delta.[12] In India, West Bengal and neighbouring Bangladesh constitute the most extensively contaminated region in the world.[6,13]

In India, chronic arsenic toxicity was first reported from Chandigarh in 1978 followed by Kolkata, West Bengal in 1984.[4] Arsenic contamination of groundwater has been reported from States of Bihar, Uttar Pradesh, Jharkhand, Chhattisgarh, Andhra Pradesh, Assam, Tripura, Manipur, Arunachal Pradesh and Nagaland.[3,10,14]

The earliest symptoms of arsenic exposure appear in skin. The skin effects are pigmentation changes (melanosis), especially on the trunk and extremities and thickening of the outer horny layer of skin (keratosis). Pigmentation and keratosis caused by arsenic are quite distinctive and are the hallmark signs of chronic arsenic exposure.[10.11,15] Arsenicosis may also cause weakness, anaemia, conjunctival congestion, chronic lung disease, peripheral neuropathy, encephalopathy, bronchitis, noncirrhotic portal hypertension (NCPH), portal hypertension, peripheral vascular disease, renal and endocrinal dysfunction.[4,5,7,11,12,16,17]

The International Agency for Research on Cancer has classified arsenic in drinking water as a "Group I" human carcinogen.[15,18] Chronic ingestion of inorganic arsenic can cause skin, bladder, kidney and lung cancer in humans.[4,10,13] Different studies conducted in Taiwan, India and Argentina shows that malnutrition increases the risk of arsenic-induced diseases in humans.[17] Arsenic can pass through the placenta to the developing foetus. Studies conducted in Bangladesh, Taiwan and Chile suggest that high arsenic exposure in drinking water during pregnancy increases risks of spontaneous abortion, stillbirth, preterm delivery, decreased birth weight and infant mortality.[7,13] Studies show that children are also affected by arsenicosis like adults. Reduced intellectual function and mental retardation of children has been reported from Thailand and Bangladesh in areas with high concentration of arsenic in drinking water.[10] Treatment of arsenicosis is mostly symptomatic. Drinking of arsenic-free water is the mainstay in the management of arsenicosis. Nutritious diet has shown to be beneficial in reducing symptoms.[4,16]

In Assam, the arsenic level in groundwater is reported to be very high and in many districts high groundwater contamination (more than WHO permitted level and GOI permitted level) of arsenic has been reported. Amongst them, the groundwater level of arsenic of Titabor block of Jorhat district has reported to be very high.[14] So, it is very important to study whether there is any adverse health impact of arsenic exposure from drinking water on people living in Titabor.

OBJECTIVES

1. To assess the prevalence of chronic arsenic toxicity (arsenicosis) in Titabor block of Jorhat district, Assam.
2. To determine the factors associated with chronic arsenic toxicity (arsenicosis) in relation to drinking water in the study population.

MATERIALS AND METHODS

Description of Study Area-

Titabor block was selected out of 7 blocks of Jorhat district as numerous reports suggest that it is the worst affected area in Assam and no study on prevalence of arsenicosis has been done till date.[19] Titabor block has a total population of 1,79,379 and literacy rate of Titabor is 67.67%. The economy of Titabor is primarily based on agriculture.

Community-based cross-sectional study was carried in Titabor block from July 2015 to June 2016. The villages were selected by cluster sampling using PPS (probability proportional to size) method. Water samples from each selected cluster were collected from groundwater samples and tested in the PHED laboratory for arsenic concentration.

Inclusion and Exclusion Criteria

Sampling and data collection.

$$n = \frac{z^2 pq}{d^2} \times g$$

Sample size was calculated to be 777 using formula considering prevalence as 50% taking allowable error as 5% (absolute error) and design effect (g) as 2. Out of 177 villages in Titabor block, 30 clusters (villages) were selected by PPS (Probability Proportional to Size) sampling method. From each selected cluster (village), 26 individuals were interviewed and examined to fulfil the required sample size. In each village, house to house survey was carried out starting from one end of the village to the other end of the village using systematic random sampling. From each selected household, an adult member was selected by simple random sampling and considered as study subject. Written informed consent of subjects was taken before using the proforma and doing clinical examination and also before water collection. If no adult member was found in the selected household, then the next household was selected for the study. The cluster where the required number of subjects was not found, study was carried out in the next village. Two groundwater (tube well) samples from each selected village were collected by simple random sampling and sent to Public Health Engineering Department (PHED), Jorhat, and Government of Assam for analysis of arsenic content in water using spectrophotometer.[20] Total 60 water samples are collected and analysed. Clinically-suspected

cases in the field were further examined in the community by a dermatologist from the Department of Dermatology, Jorhat Medical College and Hospital.

Statistical Analysis

The data collected were entered in Microsoft Excel 2007 for windows and analysed using Epi info version 7 and Microsoft Excel and SPSS version 18 (trial version).

Ethical Considerations

Ethical clearance was obtained from Institutional Ethics Committee (Human), Jorhat Medical College, Jorhat, and the ethical guidelines were followed throughout the study.

Inclusion and Exclusion Criteria

Inclusion Criteria

From each selected household, an adult member was selected by simple random sampling by using random number table and considered as study subject.

Exclusion Criteria

Individuals refusing to give consent for study and individuals residing in study area for less than 6 months was excluded.

Definitions

While carrying out the study, following case definitions were used as defined by WHO, which has acceptable sensitivity (>80%) and specificity (>80%) for the prevalent arsenic-associated skin lesions.[1]

1. Arsenicosis.
2. Clinically suspected case.
3. Probable case.
4. Clinically confirmed case.
5. Non-arsenic case.

RESULTS

Sociodemographic Characteristics

Age Group (in Years)	Sex (n=780)			
	Female	Percentage	Male	Percentage
18-30	67	8.5	43	5.5
31-40	98	12.5	94	12.0
41-50	84	10.7	121	15.5
51-60	68	8.7	64	8.2
61-70	32	4.1	61	7.8
71-80	15	1.9	23	2.9
≥80	3	0.38	7	0.8
Total	**367**	**47.0**	**413**	**53**

Table 1. Table Showing Distribution of Study Subjects According to their Age and Sex

Majority of study subjects (53%) were male and 47% were female. Amongst the men, majority (15.5%) were in the age group 41 to 50 years and amongst the female, majority (12.5%) were in the age group of 31 to 40 years (Table 1).

Occupation	Number (n=780)	Percentage
ASHA worker	3	0.3
Businessman	16	2.1
Daily wage earner	9	1.1
Farmer	219	28.1
Housewife	291	37.3
Retired tea garden worker	22	2.8
Government service	18	2.3
Student	2	0.2
Tea garden worker	200	25.6
Total	**780**	**100.00**

Table 2. Table Showing Distribution of Study Subjects According to Occupation

Majority (37.31%) of the study subjects were housewife, followed by farmers (28.08 %) and tea garden worker (25.64%) (Table-2).

Skin Manifestations

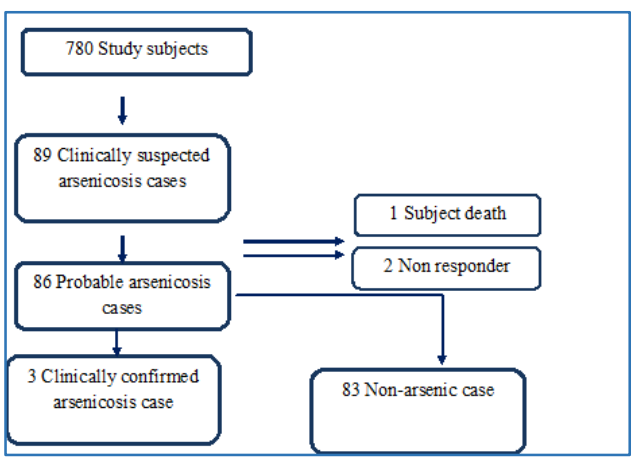

Figure 1. Figure Showing Clinically Confirmed Arsenicosis Cases among Study Subjects

In the present study, out of total 780 individuals, 89 (11.4%) cases were clinically suspected arsenicosis cases. Of them, 3 (3.37%) cases could not be followed up (one death and two nonresponder). Therefore, 86 (96.62%) cases (-probable cases) could be examined by dermatologist in the community and 3 were clinically confirmed as arsenicosis case (Figure 1). The mean age of the arsenicosis cases was 65 years. The percentage of clinically confirmed arsenicosis was observed to be 0.38% of the total study sample (780). So, from the present study, the prevalence of arsenicosis was found to be 0.38±0.019% (95% CI).

Out of 89 clinically-suspected cases, 83 (93.25%) cases were diagnosed as non-arsenic cases (Figure 1). The non-arsenic cases include- tinea infection, melasma, occupational keratosis, photo dermatitis, pityriasis versicolor, contact dermatitis, acanthosis nigricans, eczema, freckles, LSC (lichen simplex chronicus), pitted keratolysis and psoriasis.

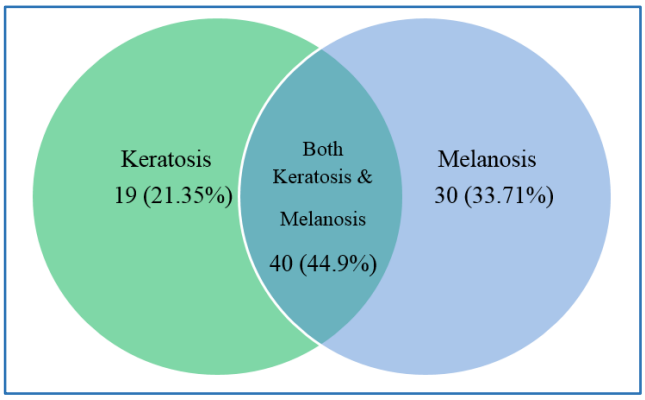

Figure 2. Figure Showing Distribution of Keratosis and Melanosis amongst Clinically Suspected Study Subjects

From the study, it was found that amongst 89 clinically suspected cases, 33.71% cases had only melanosis, 21.35% cases had only keratosis. It was found that 44.9% of clinically suspected cases had both keratosis and melanosis (Figure 2).

Sex	Melanosis (%)	Keratosis (%)
Female	43 (43.31%)	25 (28.08%)
Male	27 (30.33%)	34 (38.2%)

Table 3. Table Showing Distribution of Melanosis and Keratosis Amongst Male and Female Clinically Suspected Cases (n=89)

From the present study, it was found that amongst 89 clinically-suspected cases, 43.31% of females and 30.33% males had melanosis. Presence of melanosis was found to be significantly high amongst females (p value 0.012). It was also found that 28.08% females and 38.2% males had keratosis.

Water Source	Melanosis			Keratosis		
	Present	Absent	P-Value (Chi-Square Test)	Present	Absent	P-Value (Chi-Square Test)
Groundwater	40	249	0.000	19	270	0.423
Surface water	30	461		40	451	

Table 4. Cross-Table Showing Source of Drinking Water and Presence of Melanosis and Keratosis

In the present study, the presence of melanosis was found significantly high amongst the groundwater consumer (P<0.05) whereas no significant difference observed regarding presence of keratosis between groundwater user and surface water user.

Drinking Water Practices

Present Drinking Water Practice- Majority of subject consumed surface water (49.2% public health engineering supply, 10.3% pond water, 3.5% river) and 37% consumed groundwater (tube well). Majority (63.5%) of study subjects do pre-treatment of water before drinking (43.2% sand filtration, 13.8% boiling and 4.4% do both sand filtration and boiling).

Past Drinking Water Practice

Majority (55%) consumed surface water (55% pond water, 3.8% river water) and 41.1% consumed groundwater (tube well). Majority (72.1%) did not practice pretreatment of water, while 19.4% used sand filter and 8.5% used boiling for treatment of drinking water in the past.

Arsenic Level in Water

Maximum concentration of arsenic in water samples was 98 µg/L, minimum concentration is 31 µg/L, while the mean concentration was 66.9 µg/L (SD 18.08).

DISCUSSION

Present study indicates the chronic arsenic toxicity (arsenicosis) prevalence in Titabor block as 0.38±0.019%. The present study is in corroboration with study done by Rahman M. et al[15] in Bangladesh. The findings of the study was similar to findings of Guha Mazumdar DN et al[16] in West Bengal. Numerous study reported higher prevalence of arsenicosis than the present study.[21,22,23,24,25,26,27] The difference found in prevalence rate might be due to difference in the arsenic level in drinking water, geographic factors, genetic factors and nutritional status[17] of the study population and drinking water practices.[28,29] In our study, it was observed that out of 89 clinically-suspected arsenicosis cases, 83 cases were diagnosed as non-arsenic cases (Figure 1). Most of these conditions constitute differential diagnosis of non-cancerous arsenicosis skin lesions according to World Health Organization. It is therefore important to identify whether a skin lesion is a confirmed manifestation of arsenicosis or it is a lesion, which only appears like arsenicosis, but belongs to a different condition.[30]

Regarding the practices of consumption of drinking water, majority of subject consumed surface water (49.2% public health engineering supply, 10.3% pond water, 3.5% river) and 37% consumed groundwater (tube well). This is in contrast to the result of the study done by Guha Majumdar DN et al[21] in Ramnagar area of West Bengal, where all the study participants (100%) used to drink water from groundwater (tube well). In the present study, majority (63.5%) of study subjects do pretreatment of water before drinking (43.2% sand filtration, 13.8% boiling and 4.4% do both sand filtration and boiling). In regards to the past water consumption practices, the majority (58.8%) study subject was found consumed surface water (55% pond water, 3.8% river water) and the majority (72.1%) did not practice pretreatment of water. Concentration of arsenic in drinking water is determined by both source of water and treatment of water before drinking.[29] However, no relevant study was found on treatment of drinking water and past drinking water practices in arsenic endemic area.

In present study maximum concentration of arsenic in water was 98 µg/L, minimum concentration was 31 µg/L,

while the mean concentration was 66.9 µg/L (SD 18.08), which is above the WHO recommended level of 10 µg/L and also above Government of India recommended level of 50 µg/L.[8,9] While the arsenic concentration of water samples found in the present study was similar to many other studies, the variations observed with other studies.[11,15,22-27] The difference observed in groundwater concentration of arsenic in the present study and other studies as well as drinking water practices (source, filtration) might be possible cause of different prevalence of arsenicosis observed in the present study.[28,29] Therefore, further studies are required to find out the factors influencing occurrence of arsenicosis in the study area.

Limitations of the Study

1) The study period was only one year. In this limited period, it was very difficult to study the prevalence of a multisystem condition like arsenicosis in a large block like Titabor.
2) In the present study, testing of hair, nail and urine samples could not be done due to non-availability of testing facility in Medical Colleges of Assam.

CONCLUSION

In conclusion, the present study reveals the presence of chronic arsenic toxicity (arsenicosis) amongst the study population. The prevalence of arsenicosis (0.38±0.019%) found in the present study was similar to some other studies conducted elsewhere in the world, although in various studies reported higher prevalence rate of arsenicosis. The arsenic concentration in the drinking water samples indicates presence of arsenic exposure of the study population through drinking water. The presence of arsenic at higher concentration than WHO and Government of India permissible limit in drinking water along with the presence of arsenicosis, which is less predominant in the study population indicates the scope of further research to find out the factor, which interacting as preventive factor in occurrence of arsenicosis. The difference in prevalence rate of arsenicosis between the present study and other studies maybe due to various factors like geographic variation leading to different arsenic levels in groundwater, drinking water practices, nutritional status of study population and genetic factors. Large scale population-based studies realised necessary to depict the actual scenario of arsenicosis and its relation to groundwater contamination with arsenic.

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