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Original Research Article

Bacteriological quality of water and diarrhoea among ethnic and non-ethnic communities of rural area of West Tripura, India

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ABSTRACT

Background: Waterborne diseases are the major causes of health seeking by ethnic and non-ethnic communities of West Tripura district of India. Safe and wholesome water is a basic requirement for good health. Microbiological contamination of water is responsible for most of the waterborne diseases and diarrhoea is still a major killer of childhood.
Methods: A community based cross-sectional study was conducted among 177 ethnic and non-ethnic households chosen by multi stage sampling from West Tripura District of North East India during June - July 2016 to assess the bacteriological quality of water and to find out its association with the occurrence of diarrhoea.
Results: Among the ethnic and non-ethnic households shallow tube wells were the source for 52.18% and 62.35 %, deep tube wells for 19.56% and 29.41%, and pipe water for 20.65 % and 5.89 households respectively. Sanitary latrines ware used in 46.73% ethnic and 50.59% non-ethnic households. In both the group filtration was practiced by 85% and no purification by 1%. Covered vessels were used for storing water in 94.57% ethnic and 95.30% non-ethnic households. Source of water was mildly contaminated in 15% ethnic and 10% non-ethnic, moderate and heavy contaminations were 11% and 8% each respectively in both the groups. At the point of consumption moderate and heavy contaminations were 2% each in ethnic households. Mild and severe contaminations were 3% and 1% respectively in non-ethnic group. Diarrhoea was significantly more frequent among households consuming coliform contaminated water ($p<0.05$).
Conclusions: Half of the study population was using insanitary latrine and one fifth were collecting water from contaminated sources. Hence provision of safe water and promotion of sanitary latrine is needed to prevent waterborne diseases in this community.

Keywords: Coliform organism, Diarrhoea, Drinking water, Sanitary latrine, Tripura

INTRODUCTION

Safe and wholesome water is a basic requirement for good health. Microbiological contamination of water is responsible for most of the waterborne diseases and diarrhoea is still a major killer of childhood. Two and a half billion people have no access to improved sanitation and more than 1.5 million children die each year from diarrheal diseases.[1] It is estimated that 37.7 million Indians are affected by water borne diseases annually, 1.5

million children are estimated to die of diarrhea alone and 73 million working days are lost due to water borne diseases each year.[2] The problem of chemical contamination is also prevalent in India. The major chemical contaminants include arsenic and fluoride.[3] Census 2001 reported that only 68.2% households in India have access to safe drinking water. According to latest estimate 94% of the rural population and 91% of the people living in urban areas have access to safe drinking water.[4] Water quality is affected by both point and non-point sources of pollution. These include sewage discharge, discharge from industry, run off from agriculture field and urban run-off.[5] Water quality is also affected by floods and droughts and also arises from lack of awareness and education among users.[6] Government of India launched the National Rural Drinking Water Quality Monitoring and Surveillance Program in February 2006.[7] But no study was conducted regarding microbiological quality of water consumed by people living in rural area of West Tripura district. Data from different health centres of West Tripura district of India has identified waterborne diseases as the major causes for seeking health care by both ethnic and non-ethnic communities. Hence the present study was designed to assess the bacteriological quality of water both at source and at the point of consumption and to find out its association with the occurrence of diarrhoea in rural area of West Tripura District of North East India.

METHODS

This community based cross-sectional study was conducted among 177 ethnic and non-ethnic households of 4 Sub-centre areas under of West Tripura District during June - July 2016. Minimum sample size requirement for this study was determined to be 147 households at 5% level of significance, considering 75.9% households having access to improved source of drinking water in rural area of Tripura, 8 20% incomplete response rate and 10% allowable error. But we could cover 177 households in total during our study period and data from all these 177 households were included in this study for analysis.

Multistage sampling technique was followed to choose the study households. In the first stage, out of 9 Blocks of West Tripura District, Mohanpur Block was chosen by 'Simple Random Sampling'(SRS). Out of 22 Health Sub-centres located in Mohanpur Block, 4 sub-centres namely: Laxmipara, Domdomia, Sepoypara and Kamalghat were chosen by (SRS) without replacement. Each of these sub-centres had a mixture of ethnic and non-ethnic population. Family registers maintained in these Sub-centres were used to construct two separate sampling frames for ethnic and non-ethnic households. Lastly from ethnic group 92 and from non-ethnic group 85 households were chosen by SRS. Households of less than one year duration, households whose heads were not willing to participate in this study and houses which might be found to be locked during three consecutive visits were initially planned to be excluded but luckily no households met exclusion criteria. A pre-tested structured interview schedule, sterile glass water bottles for collecting water sample and 'Mc Conkey Agar' media for culturing microorganisms were used in this study.

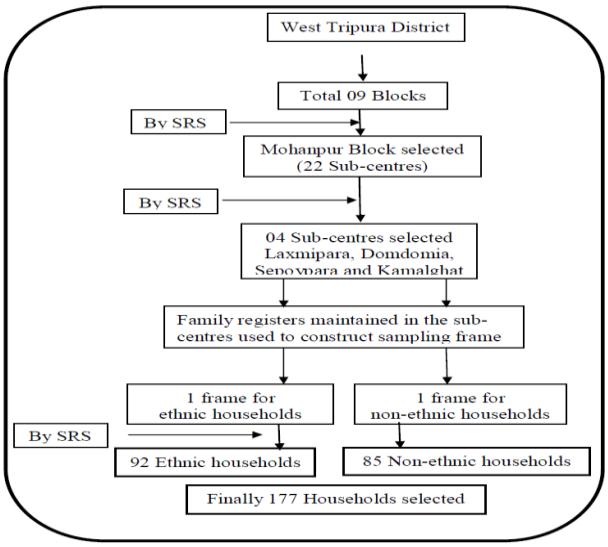

Figure 1: Sampling algorithm.

Subjects belonging to scheduled tribe community were considered as 'ethnic' and other than scheduled tribes were 'non-ethnic'. Subjects who were not enrolled in school for formal education were 'illiterate', 'primary educated' were those who studied any level up to standard VIII and 'secondary and above' educated were those who studied up to any level above standard VIII. Modified B G Prasad's socioeconomic classification 2016 was used to classify the socioeconomic status of the study families.[9] Coliform organisms were defined as the bacteria resembling *Escherichia coli* and their presence in water was considered as faecal contamination. Presence of 1-3 coliform organisms per 100 ml of water was labeled as mild, 4-9 per 100 ml as moderate and ≥10 per 100 ml as heavy contamination of water. History of 3 consecutive loose motions in a day was considered diarrhoea and its occurrence in any member of the study households within 15 days prior to the survey was recorded as incidence of diarrhoea.

Being accompanied by the Medical Social Workers (MSW) of the Community Medicine Department, the ANMs and the ASHAs posted in the study area, home visits were paid to the selected households. After identifying the selected households either the head of the family (HOF) or some adult members (if head is not present) were approached and informed consent for participating in this study was sought. Consenting heads / adults from each household were interviewed confidentially in presence of the ANM / MSW / ASHA and the statements were recorded in the pretested interview schedule, which included socio demographic information like: residence, income, occupation,

education, ethnicity etc. and practice based questions like: the source of water, its storage, method of purification if any and occurrence of diarrhoea during last 15 days' period among any member of the households etc.

Water samples were collected with proper precautions as governed by the guidelines of the World Health Organization for the quality of drinking- water both from the source and point of consumption for each household using sterile screw capped 100 ml glass bottles prepared from Microbiology Department of the institute.[10] The procedure of collecting water sample was individualized per the source. While collecting samples from piped sources like water tap, tube well, and filter, the water could run to waste for 2 to 3 min then allowed into the bottle and capped avoiding hand contamination. For collection of sample from streams or lakes, bottle was dipped to a depth of about 30 cm with its mouth facing the current and then uncapped allowing water inside the bottle and recapped maintaining minimum hand contact. Water samples were labeled properly and transported to the Microbiology Department of the institute for bacterial culture using MacConkey Agar broth. Coliform count was determined using Most Probable Number (MPN) of bacteria presumed to be coliform bacteria. The estimation of coliform bacteria was performed by using reference statistical tables.[11]

Data entry and analysis were performed in computer using SPSS version 12 ensuring confidentiality and presented by means of tables and charts. Descriptive statistics like frequency, proportion etc. were used to summarize the data. Chi square test was used to see the association between variables and logistic regression analysis was also performed. A p-value of less than 0.05 was considered statistically significant. Prior permission for conducting this study was obtained from the competent authority of Agartala Government Medical College.

RESULTS

There were 92 ethnic and 85 non-ethnic households in this study and response rate was 100%. From the ethnic group 20% of the head of families (HOF) did not have any formal education, 54.11% were primary educated and 25.89% were either secondary educated or above.

Table 1: Presence of coliform organisms in the source of water by the type of source, literacy of the HOF, religion, ethnicity, socio-economic status and type of latrine.

Variables	Sub-types	Coliform organisms		Significance
		Present, n (%)	Absent, n (%)	
Type of source	Tube well	43 (30.0)	101 (70.0)	χ^2=9.558 p=0. 008
	Pipe water	06 (25.0)	18 (75.0)	
	Well, pond, stream etc.	07 (77.8)	02 (22.2)	
Literacy	Literate HOF	37 (27.6)	97 (72.4)	χ^2=3.404 p = 0. 065
	Illiterate HOF	19 (44.2)	24 (55.8)	
Religion	Hindu	51 (30.5)	116 (69.5)	χ^2=0.875 p=0. 349
	Christian and others	05 (50.0)	05 (50.0)	
Ethnicity	Ethnic households	31 (34.0)	61 (66.0)	χ^2=0.567 p=0. 451
	Non-ethnic households	25 (29.0)	60 (71.0)	
Socioeconomic status	Upper middle class	01 (7.7)	12 (92.3)	χ^2=5.370 p=0. 068
	Middle class	08 (24.2)	25 (75.8)	
	Lower middle class	47 (35.9)	84 (64.1)	
Type of latrine	Sanitary latrine	15 (17.4)	71 (82.6)	χ^2=14.337 p=0. 000
	Insanitary latrine	41 (45.0)	50 (55.0)	

Table 1 shows that coliform contamination of water was significantly more frequent where the sources were either well, pond or stream etc. and the latrines were insanitary in nature ($p<0.05$).

Among the non-ethnic group 28.26% of the head of families had no formal education, 35.87% each were primary educated and either secondary or above educated.

Majority of the families were Hindu by religion. Among the ethnic population majority (38.04%) of the heads of families were government servants whereas, majority (35.29%) of the heads from non-ethnic household had their own business and most of the families belonged to lower middle class as per modified B G Prasad's Socioeconomic classification 2016. It was found that 95.30% of the ethnic and 85.87% of the non-ethnic population had sources of water located within 50 meters from their houses. Shallow tube wells were the sources of water for 52.18% of the ethnic and 62.35 % of the non-ethnic households. Water from deep tube well was available to 19.56% of the ethnic and 29.41% of the non-

ethnic households and pipe water was available to only 20.65 % of the ethnic and 5.89% of the non-ethnic households. Sanitary latrines ware available only in 46.73% of the ethnic and 50.59% of the non-ethnic households.

Table 2: Degree of coliform contamination of the source of water by it's type, ethnicity of population, literacy of HOF and the type of latrine (Total number of contaminated sources = 56).

Variables	Subtypes	Degree of contamination		
		Mild n (%)	Moderate n (%)	Severe n (%)
Type of source	Tube well	33 (76.74)	07 (16.30)	03 (6.96)
	Pipe water	05 (83.33)	01 (16.66)	00
	Well, pond, stream etc.	01 (14.28)	01 (14.28)	05 (71.44)
Ethnicity	Ethnic households	15 (48.39)	11 (35.48)	05 (16.13)
	Non-ethnic households	10 (40.00)	11 (44.00)	04 (16.00)
Literacy	Literate HOF	27 (72.97)	08 (21.62)	02 (5.41)
	Illiterate HOF	11 (57.89)	06 (31.58)	02 (10.53)
Type of latrine	Sanitary latrine	08 (53.33)	05 (33.33)	02 (13.34)
	Insanitary latrine	25 (60.98)	10 (24.39)	06 (14.63)

Table 2 shows that severe coliform contamination of water was detected in the households whose sources of water were well, pond, stream etc. and the latrines were insanitary in nature.

Table 3: Presence of coliform organisms in the drinking water by the source of water, purification process and retrieval, type of latrine, literacy of the HOF, ethnicity and socio-economic status.

Variables	Sub-types	Coliform organisms	
		Present, n (%)	Absent, n (%)
Source of water	Tube well	01 (0.70)	143 (99.30)
	Pipe water	00	24 (100.00)
	Well, pond, stream etc	03 (33.33)	06 (66.67)
Purification	Filtration	05 (3.30)	147 (96.70)
	Boiling & others	01 (4.35)	22 (95.65)
	No purification	02 (100.00)	00 (0.00)
Storage	Covered container	04 (2.36)	165 (97.64)
	Uncovered container	04 (50.00)	04 (50.00)
Retrieval	Through tap	02 (1.34)	147 (98.66)
	Tilting the container	02 (8.33)	22 (91.67)
	Dipping pots inside	04 (33.33)	08 (66.67)
Type of latrine	Sanitary latrine	02 (2.33)	84 (97.67)
	Insanitary latrine	06 (6.59)	85 (93.41)
Literacy	Literate HOF	06 (4.48)	128 (95.52)
	Illiterate HOF	02 (4.65)	41 (95.35)
Ethnicity	Ethnic households	04 (4.35)	88 (95.65)
	Non-ethnic households	04 (4.70)	81 (95.30)
Socioeconomic status	Upper middle class	00 (0.00)	13 (100.00)
	Middle class	01 (3.03)	32 (96.97)
	Lower middle class	07 (5.34)	124 (94.66)

Table 3 shows that detection of coliform contamination was more frequent among households where drinking water was collected from well, pond, stream etc., adopted no method of purification, stored in uncovered vessels, retrieved by dipping pots inside the storage, used insanitary latrine and belonged to low socioeconomic status.

Filtration was practiced in more than 85% of both ethnic and non-ethnic study households and only in little more than 1% of the households no method of water purification was followed. In 94.57% of the ethnic and 95.30% of the non-ethnic household's water was stored in covered vessels before consumption. Drinking water samples from 98.91% of the ethnic and 96.47% of the non-ethnic households were apparently free from turbidity, samples from 95.65% of the ethnic and 95.30% of the non-ethnic households were free from unpleasant taste and all the samples from both ethnic and non-ethnic households were found to be odourless.

Samples collected from the sources of water in 61 (66%) ethnic and 60 (71%) non-ethnic households were free from coliform organisms, whereas mild coliform contamination was detected in water sources from 15% and 10% households from the ethnic and non-ethnic households respectively.

Table 4: Cases of diarrhoea reported from households by the presence of coliform organisms in water.

Water	Coliforms	Episodes of diarrhoea		Significance
		Reported, n (%)	Not reported, n (%)	
At source	Detected	10 (17.86)	46 (82.14)	χ^2=5.111
	Not detected	7 (5.78)	114 (94.21)	p=0. 023
Consumption Point	Detected	07 (87.50)	01 (12.50)	P=0.000*
	Not detected	10 (5.92)	159 (94.08)	

Table 4 shows that significantly higher number of households reported episodes of diarrhoea among the family members whose water at source and the point of consumption were contaminated with coliform organisms ($p<0.05$). *Fishers exact test.

Table 5: Binary logistic regression analysis.

Variables	Subgroups	Odds ratio (95% CI)	P - value
Source of water	Tube well and pipe water	1	0.023
	Well, pond, stream etc.	2.473 (2.376–4.055)	
Purification	Filtration, boiling etc.	1	0.003
	No purification done	3.462 (2.983–5.071)	
Water storage	Covered container	1	0.255
	Uncovered container	2.641 (0.482–2.735)	
Retrieval	Through tap	1	0.065
	By tilting and dipping a pot	4.621 (0.352–5.211)	
Type of latrine	Sanitary	1	0.014
	Insanitary	3.171 (2.739–4.062)	
Literacy of HOF	Literate	1	1.065
	Illiterate	2.131 (0.962–2.472)	
Ethnicity	Non-ethnic	1	0.375
	Ethnic	1.548 (0.467–3.032)	
Socioeconomic status	Upper middle class	1	0.431
	Middle and lower middle class	2.042 (0.833–3.975)	

Table 5 shows that binary logistic regression analysis has identified well, pond, stream etc. as the sources of water, p = 0.023, (OR = 2.473, 95% CI = 2.376 – 4.055); No purification of water before drinking, p = 0.003, (OR = 3.462, 95% CI = 2.983 – 5.071) and using insanitary latrine, p = 0.014, (OR = 3.171, 95% CI = 2.739 – 4.062) as the significant predictors for occurrence of diarrhoea while the others did not attain the level of statistical significance.

Moderate contamination was detected in 11% and heavy contamination was detected in 8% households of both the groups. Drinking water samples from 96% of the ethnic and 95% of the non-ethnic households were found to be free from coliform organisms. Moderate and heavy coliform contamination of drinking water was found to be 2% each in ethnic households. Mild and severe coliform contamination in the samples obtained from non-ethnic households was 3% and 1% respectively.

DISCUSSION

Present study has detected that 11% of the ethnic and 8% of the non-ethnic households in rural area of West Tripura District were collecting water from sources which were heavily contaminated with coliform organisms but Mukhopadhyay C et al in Karnataka have found that 22 (27.5%) water samples and the majority (92.5%) of the water sources were contaminated with coliforms.[13] This variation may be due to site and nature of the source of water. Tambe PV et al in Western Maharashtra have found that overall 49.8% of the water samples were polluted and 45.9% of the samples from piped water supply were also polluted.[6] This may be due to leaks in the pipelines. Singh US et al in-Himachal Pradesh have found all the 14 surface water samples collected from bowries were polluted with total coliform count ranging from 35 - 1800+.[14] Singh AK et al also observed unsatisfactory microbiological quality of water in 28% and 4% of tap and filter water samples respectively in a study conducted in an urban area of Punjab.[15] This finding is at per with our findings. Malhotra S et al have found that 42.9% (565/1,317) samples from various sources were unfit for human

consumption.[16] Similarly Antony RM et al in Tamilnadu have found faecal coliform counts to vary from 12 to 180 MPN/100 ml and Escherichia coli counts to range from 6 to 161 MPN/100 ml in all the sampled sites.[17] All these variations may be attributable to the quality of construction of the sources. In rural and peri urban areas of Sudan the sources of water as well as the point of consumption showed coliform counts in excess of WHO standards, which were similar to the findings of other authors also.[18-20] Of course the relationship between the prevalence of diarrhoea and the quality of drinking water is complex.

The case specific routes that lead to diarrhoeal diseases are extremely difficult to identify. Furthermore, there are numerous and distinct pathogen types involved in diarrhoeal diseases that can infect a new host via multiple pathways.[21] Most water treatment / storage interventions, sanitation practices, and health education in several other studies have been shown to be effective and yet high indicator bacteria counts were seldom associated with diarrhoea.[22,23] The source of water quality degradation during distribution increases the rate of gastrointestinal illnesses.[24] In addition, as people can become infected with diarrhoea causing organisms in multiple ways, transmission of diarrhoea may not be intercepted by improving the quality of water alone.[25] Despite effective treatment of drinking water, microbes can enter water utility distribution systems.[26] Due to resource constrains this study could not incorporate representation from wider areas of West Tripura District in the study sample by using either cluster sampling or other techniques, which might have strengthened the external validity.

CONCLUSION

Coliform contamination of water at source was detected in 11% of the ethnic and 8% of the non-ethnic households from rural area of West Tripura district of India. Occurrence of diarrhoea was found to be significantly higher among households where coliform contamination of water was detected. A sizeable proportion of households from both the communities were still found to be using insanitary latrines. Logistic regression analysis has identified water sources like well, pond, stream etc., drinking of unpurified water, and use of insanitary latrines as the significant risk factors for occurrence of diarrhoea in this community. Provision of safe sources like tube well or pipe water and promotion of low cost sanitary latrines through programs like 'Total Sanitation Campaign' may help to protect the study population from waterborne diseases.

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