Original Article

Assessment of Bacteriological Quality of Drinking Water and its Gastrointestinal Health Effects on Residents of Vadodara City

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Abstract

Aims: The present study was conducted to assess the gastrointestinal health effects and other health effects due to consumption of drinking water, to analyze the water quality parameters (bacteriological and free residual chlorine), and to find out the methods of purification of water at household level and hand washing technique among people in urban Vadodara. **Materials and Methods:** A cross-sectional study was carried out at urban Vadodara city. 2609 participants were included in the study from among 720 households. 60 households from each selected water tank area were included. Interviews were conducted to know the health effects of water as well as method of purification, hand-washing technique, and the history of gastrointestinal problems. Thirty-eight water samples were tested hydrogen sulfide (H_2S) strip test and multiple tube method. **Results:** 4.21% had history of diarrhea in the last 2 weeks. 0.99% had typhoid and 0.65% had history of Jaundice in the past year. H_2S Strip test was Negative and no single coliform was found in all 38 water samples. The free chlorine levels in all the tanks were found to be higher than the normal levels. 43.05% participants were using simple cloth or sieve for purification of water followed by 35.97% participants were using reverse osmosis. 14.25% participants were not washing hands before cooking while 5.13% participants were not washing hands after going toilet. **Conclusion:** Supplied drinking water was bacteriologically safe. Despite that history of diarrhea, typhoid and jaundice was found in the study area.

Keywords: Bateriological quality, drinking water, gastrointestinal health effects, health effects

Introduction

About 26% of the world population lacks access to basic sanitation.[1] Diarrhea kills more people than injuries, suicide, homicide, terrorism, and among under 5 children, making it the third leading cause of death following pneumonia and preterm birth complications.[2] Each year around 37.7 million Indians are affected with water borne diseases of which 1.5 million are children.[3]

Diarrhea is most widely known disease linked to contaminated food and water, but there are other sources. Drinking water storage containers serve as breeding grounds for bacteria and parasites causing gastrointestinal disease. Contaminated water spread diseases such as cholera, diarrheal disease, dysentery, gastroenteritis, giardiasis, hepatitis E, and typhoid fever.

Yet diarrhea is largely preventable if risk factors are addressed. Clean water, basic toilets and good hygiene practices are essential for the survival and development of children. Inadequate prioritization of hand washing leads to the likelihood of diarrhea and other diseases.

Studies conducted by Negasa Eshete Soboksa in Ethiopia showed that sources of drinking water, hand washing before water drawing from a storage container, domestic waste disposal place and use of soap for hand washing were the most important factors for the prevention of childhood diarrhea. Improving household drinking water quality and changing people's behavior toward safe sanitation practices is an important mechanism to protect the risk of childhood

Access this article online

Quick Response Code:

Website: www.ijehe.org

DOI: 10.4103/ijehe.ijehe_27_22

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How to cite this article: Patel SV, Khokhariya RD, Rathod J, Chatterji DG, Patel J. Assessment of bacteriological quality of drinking water and its gastrointestinal health effects on residents of Vadodara city. Int J Env Health Eng 2023;12:19.

Received: 30-07-2022, **Accepted:** 23-05-2023, **Published:** 31-08-2023

diarrhea.[4,5] The disability adjusted life years rate (per 100,000 population) in India for diarrhea was 6544 in 1990 which however has declined to 1446 in 2019.[6]

According to the World Health Organization (WHO), the objectives of a water safety plan are to ensure safe drinking water through good water supply practices.[7]

Certain programs, such as Centers for Disease Control and Prevention (CDC's) safe water systems, can empower people to improve and protect the quality of their drinking water through simple, inexpensive technologies to treat and safely store water in their homes. The intervention consists of point of use treatment of contaminated water, safe water storage, improved hygiene, behavior change techniques.[8]

In India, Jal Jeevan Mission in August, 2019 was initiated to accelerate the efforts to achieve universal sanitation coverage and to provide adequate safe drinking water through individual household tap connection to all households in rural India by 2024. It is predicted that this program will benefit more than 19 crore rural families.[9]

The present study was conducted to assess the gastrointestinal health effects and other health effects due to consumption of drinking water, to analyze the water quality parameters (bacteriological and free residual chlorine) and to find out the method of purification of water at household level and hand washing technique among people in urban Vadodara.

Materials and Methods

The study was conducted after taking permission from Institutional ethical committee. A cross-sectional study was carried out at urban Vadodara city. Average 3 water tanks were selected randomly from purposively assigned zones of north, south, east and west areas in the city. Hence water sample from 12 water tanks were tested. From the areas supplied by these 12 selected water tanks, two water samples each, one from near tank area and another from outer limit of water supply were collected from household level for water quality analysis confirm variation in quality if any. Thus, total 12 water tank samples, 24 household water samples, and 2 from main water bodies of Vadodara district (Ajwa and Mahi river) (38 samples) were tested. Standard operating procedure was followed for water sample collection and transport. The water samples were sent to the public health laboratory (PHL) for hydrogen sulfide test strip (H_2S strip test), multiple tube method (maximum coliform and maximum fecal coliform), and residual chlorine.

According to the census of 2011, the approximate population of Vadodara city is 16,66,495. Considering the average household size of 5, total households of Vadodara city are estimated to be about 333,299. Interviews were conducted in 60 households taken from each of the 12 water supplying tank area (total of 720 households) were taken. Assuming the average family size of 5 persons, the expected total population to be covered was 3600. However, 2609 participants were available during data collection and consent was taken for participation. For the purpose of interview to know the health effects of water as well as method of purification a pre validated and semi structured questionnaire was used to collect data from 60 households from each selected water tank area after taking written consent. All the member of these households was included in the study. 1st house was randomly selected after which 60 sequential houses were included for the study. If any house was closed than sequential next house was selected. Questionnaire was used for data collection for variables such as hand washing practices, history of gastrointestinal diseases (diarrhea, typhoid, jaundice), household level of water purification methods and duration of RO usage was included. As per the WHO guidelines, diarrhea was defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual) occurring within the last 3 months of the survey. History of typhoid and jaundice was taken within the past 1 year of data collection.

The total study duration was 1 year and the data were collected from November 2016 to August 2017. Exclusion criteria for study were those families who used bore well water, who lived in slum area and flat/apartment area.

The process of data collection did not pose any potential risk or harm to the participants. Data safety and confidentiality was given due consideration by keeping the file containing identity related details password protected. The filled pro forma were kept in lock and key accessible only to researchers. The drinking water quality samples were defined and compared with WHO water quality standards.

Statistical Analysis: The Data was entered in Microsoft excel worksheet 2007 using strict check files. Water quality parameters were measured in pre-defined measures. Chi square and Fishers exact test was used for categorical data using Epi info 7 (Atlanta, Georgia, USA).[10]

Results

Total 2609 participants were included in the study from 720 households. Out of these total 2609 participants, 1340 (51.36%) were male and 1269 (48.63%) were female. 1841 participants which is nearly three fourths of the participants (70.56%) of the participants were between 20 and 64 years, 311 (11.92%) participants were between 10 and 19 years, 167 (6.40%) participants were above 65 years age, 165 (6.32%) participants were <5 years, 125 (4.79%) were between 6 and 9 years.

Most of the participants were graduates 1074 (41.16%), followed by 500 (19.16%) participants who had education up to higher secondary level sand one tenth of the participants were illiterate.

Figure 1 shows that all the participants were using some kind of purification method. None of the participants used boiled water or chlorine tablet for drinking purpose at household level. 310 (43.05%) participants were using simple cloth or sieve for purification of water. 259 (35.97%) participants were using

reverse osmosis (RO). 147 (20.41%) participants were using ultraviolet (UV) filter for purification of water.

In Figure 2, 406 participants were RO/UV water filter users of which 141 (34.72%) household had been using RO/UV water for <5 years, 160 (39.40%) households for 5–10 years and 105 (25.86%) for more than 10 years. All RO/UV users had annual maintenance contract (AMC) of the filters. Among these users, 7 (1.72%) had their RO filters cleaned once a year, 176 (43.34%) cleaned twice a year, 163 (40.14%) cleaned thrice a year and 60 (14.77%) cleaned four times a year by the AMC companies.

As shown in Table 1, 1803 (69.10%) participants were washing hands before cooking and 372 (14.25%) participants were not washing hands before cooking and 434 (16.63%) participants not applicable as they were small children or elderly people who don't cook. 2475 (94.86%) participants washed hands after going toilet and it was not applicable to 134 (5.13%) participants as they were children <5 years of age.

Coliform count in all the samples from the selected tanks was found to be zero. H_2S strip test was Negative in all the water tanks. All 38 water samples were bacteriologically safe. The normal level of free chlorine is 0.5 parts per mol (ppm). The free chlorine levels in all the tanks were higher than the normal levels. Highest of 1.940 ppm was found in the Lalbaugh water tank. 0.5 ppm was found in Harni and Ajwa. Rest of the tanks had 1 ppm at the tank level. Free chlorine was 2 ppm in Gorwa, Manjalpur and GIDC area and 1 ppm was recorded in all the water tanks of places near and far from the main tank. This showed that all the samples of water (from the source of the water up to user level) were bacteriologically safe for drinking purpose.

Table 2 shows that 4.21% participants had history of diarrhea, 0.99% participants had history of typhoid, and 0.65% had history of jaundice.

Out of the total 2609 participants, 110 (4.21%) had history of diarrhea in last 3 months. 51 (46.36%) number of participants were below the age of 5 years, 11 (10%) were between the age of 6–9 years, 10 (9.09%) were between the age 10–19 years, 35 (31.81%) were between the age 20–64 years and 3 (2.72%) were above 65 years.

Discussion

A safe and convenient water supply plays a vital role in public health and well-being of the society.[11] Inadequate water, sanitation and hygiene (WASH) can cause various adverse health outcomes, through a number of different transmission pathways including ingestion of water (e.g., diarrhea, arsenicosis, fluorosis); inadequate supply of water is linked to inadequate personal hygiene (e.g., diarrhea, trachoma, scabies).

In all, 38 samples of water were checked. H_2S strip test was negative, maximum coliform count was zero, maximum fecal coliform count was zero, and free chlorine ranged from 0.5 to 1.940 ppm. The water samples were bacteriologically safe not only at tank level but also in all samples taken near and far from the tanks at user level. Thus all 38 water samples were bacteriologically safe. This fulfills Sustainable Development Goal 6.1 that calls for universal and equitable access to safe and affordable drinking water for the residents of Vadodara.

Collection and storage along with handler's personal hygiene is as important as treatment and transport of water at household level. If it is not stored and handled properly, it leads to various water borne infections causing people to become sick. The storage container itself needs to be clean and water should not

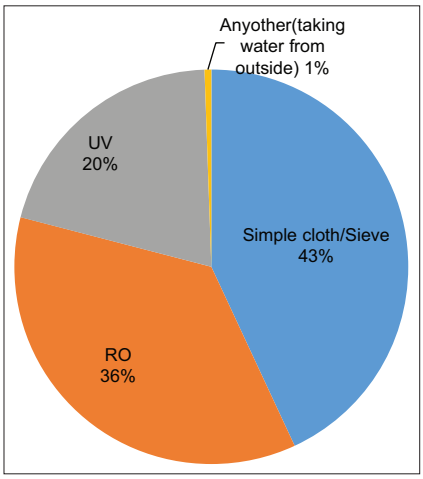

Figure 1: Water purification method used by study participants (n = 720)

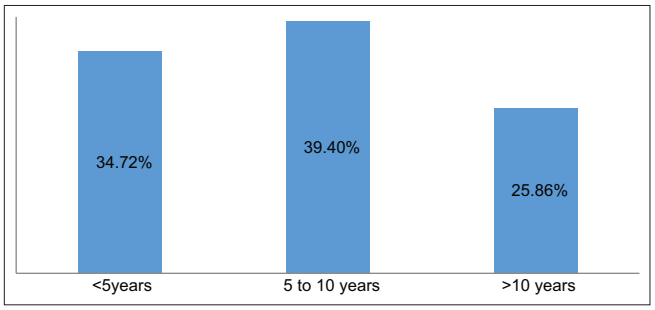

Figure 2: Duration of RO use (n = 406). RO: Reverse osmosis

Table 1: Hand washing practices by study participants (n=2609)

	Yes, n (%)	No, n (%)	Not applicable, n (%)
Washing hands before cooking	1803 (69.10)	372 (14.25)	434 (16.63)#
Washing hands after going toilet	94.86	0	134 (5.13)*

*Not applicable are small children <5 years of age, #Not applicable are small children, girls and boys who don't cook, elderly people

Table 2: History of gastrointestinal disease and other health problems among study participants

Gastrointestinal diseases and other health problems	Study participants, *n* (%)	CI (%)
Diarrhea	110 (4.21)	3.49–5.08
Typhoid	26 (0.99)	0.67–1.48
Jaundice	17 (0.65)	0.39–1.06

CI: Confidence interval

be recontaminated by touching the water with unclean hands or unclean utensils to pour water.[12]

The District Level Health Surveys (DLHS) offers the relevant information-base to verify the possible association between the prevalence of diarrhea and the key WASH indicators of safe drinking water and sanitation facilities. The household prevalence of diarrhea was 12% and that of clustering of diarrhea was 2.4%. About 6.5% of households contributed 12.6% of the total diarrheal cases. Data from DLHS-3 and NFHS-4 in India shows the prevalence of diarrhea and percentage of household with sanitation was 10.4%–92.0% in the period 2015–2016. Data from NFHS 5 in India shows the prevalence of diarrhea was 5.5% in 2 weeks preceding the survey. According to DLHS3, 4.21% had history of diarrhea in last 3 months which is less as compared to the data of NFHS 5.[13,14] The data of our study was taken for duration of 3 months whereas the data from NFHS 5 was taken over 2 weeks preceding the survey. As mentioned in the results, water of Vadodara city was bacteriological safe. The prevalence of diarrhea was less compared to other studies. Hence storage of water at house hold level and personal hygiene need to be monitored.

A study conducted by Ramanathan and Vijayan showed that access to safe water and sanitation had greater impact on reduction of diarrhea prevention where safe water alone had greater impact on reduction in the prevalence in the absence of improved sanitation when compared with the presence of improved sanitation.[15] Our study shows that 4.21% (confidence interval [CI] 3.49–5.08) participants had a previous history of diarrhea within the past 3 months of the study duration.

The WHO, CDC, and other agencies involved in protecting consumers' health agree that washing hands has to be performed: Before starting the cooking process, during and after cooking, before eating, and after using the toilet every time. Washing hands in households is mentioned as one of the targeted hygiene measures that have to be taken every time the probability and level of contamination is high.[16] We found that 14.25% participants in our study were not washing hands before cooking while 5.13% participants were not washing hands after going toilet.

Hand-washing promotion among communities in low and middle income countries probably prevents around one-quarter of diarrhea episodes (Incidence rate ratio (IRR) 0.71, 95% CI 0.62–0.81; 9 trials, 15,950 participants; moderate-certainty evidence).[17]

According to NFHS5 of Gujarat conducted in 2019–2020 by ministry of health and family welfare, 22% of the household use appropriate treatment to make water potable mostly by straining by cloth.[13] Our study shows 43.05% participants were using simple cloth as a sieve for purification of water for domestic use. 35.97% participants were using RO and 20.41% were using UV filter for purification of water. It is interesting to note that none of the participants were boiling water.

Limitation of the study includes possible recall bias during data collection. The study was not conducted during monsoon season. This may give varied results when there is seasonal variation. Further studies needs to be conducted during monsoon season. Other causes of ill effects of gastrointestinal health among the subjects maybe due to water consumption from other sources apart from individual households. To avoid measurement bias, all equipment had been standardized and calibrated prior to the study.

Conclusion

Drinking water available to the people of Vadodara supplied by the Vadodara municipal corporation was bacteriologically safe. In our study 43.05% participants were using simple cloth or sieve for purification of water, 36% participants were using RO system and 20% were using UV filter. Diarrhea in children below 5 years of age was high 46.36%.

Acknowledgment

Special thanks to Dean and Microbiology Department of Government Medical College, Vadodara for giving permission to carry out free of cost bacteriological investigation of water samples at PHL.

Ethical Code: ECR/85/Inst/Gj/2013.

Financial support and sponsorship

No grant was received for this project; however, all the laboratory investigations of multiple tube method, H_2S strip test, and residual chlorine were done free of cost by the permission of Dean, Microbiology Department and PHL.

Conflicts of interest

There are no conflicts of interest.

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