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HEALTH RISKS ASSOCIATED WITH SOURCES OF WATER: AN EXPLORATORY STUDY FROM TURAG-TONGI RIPARIAN AREAS, BANGLADESH

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Abstract

The present study aims to investigate the available water sources for drinking and domestic purposes and their relationship with the occurrence of diseases in a given community. To accomplish this, 1826 households in the Turag River area of Tongi at twelve different locations were surveyed. Six focus group discussions (FGDs) and twelve key informant interviews (KIIs) were also conducted in six different Turag River locations. Data on water quality has been gathered from various government surveys (BNDWQS, 2011; BBS, 2017; SVRS, 2019, etc.), international reports (WHO, World Bank, etc.), individual studies, and other relevant sources. Of all the recorded (13) drinking water sources, motorized tubewells were the most common and were used by 73.8 percent of respondents. Other sources include pipe connections into the yard (16.7%) and dwelling (4.5%), deep and shallow tube wells (2.6%), public tap water (2.1%) etc. The study also revealed that a notable percentage (2.8%) of the survey population still depended on open sources such as rainwater, rivers, lakes, ponds, etc., for drinking and domestic purposes. The respondents also reported the presence of yellow crust (iron) and other unwanted components in their water sources, with foul odors and unpleasant tastes. It has also been documented that the communities have been suffering from various diseases, such as diarrhea, skin diseases, dysentery, malaria, jaundice, typhoid, tuberculosis, pneumonia, cholera, etc. diseases over the past year. The Spearman's rho (ρ's) test showed significant associations between these diseases and the water sources. The issues identified by the present study are likely to aid policymakers in including water and health concerns in national policy and ensuring access to sustainable water resources, aligning with SDGs 6.1, 6.3, and 6.4.

Keywords: Sources of water, disease incidence, water quality, river, drinking water.

Introduction

Access to safe and clean water is a fundamental human right, and its importance cannot be overstated when maintaining good health. Yet, for several decades, roughly a billion people in developing nations lacked access to reliable, safe water sources (Hunter *et al.,*

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2010). It has been estimated that 2.1 billion people worldwide (29% of the world's population) have no access to safe drinking water and are responsible for 1.2 billion deaths yearly (Hannah and Max, 2021). Over 70 percent of the urban population in developing countries either lack adequate water supplies, or receive unsafe water, or both (Kamal, 2003). Safe drinking water availability in urban areas is a major challenge (Zuthi *et al.,* 2009) due to the steady population growth, declining groundwater availability, and river water pollution (Nahar *et al.,* 2014; Parvin *et al.,* 2022; Xu *et al.,* 2022).

Drinking water quality is essential to human health, as 80 percent of diseases worldwide are linked to poor drinking water quality (Lin *et al.,* 2022). While Bangladesh has made significant progress in providing universal access to improved water sources, access to safe drinking water remains 41 percent (1.8 million out of its 165 million people) in 2023 (Water.org, 2023). Bangladesh faces an enormous challenge in supplying safe water to the capital city's fast-growing population (ABD, 2013), resulting in many households heavily relying on a combination of safe sources such as shallow tube wells, piped water supplies, etc., and unsafe sources, such as rivers, canals, dug wells, rainwater, water vendors, etc., to meet their daily water needs (ABD, 2013; Roy and Dutta, 2017). Poor sanitation practices, industrial waste, and agricultural runoff put these water sources at risk of contamination. Due to the practice of discharging untreated domestic and industrial waste, rivers in urban areas have also been linked to water quality issues. This has increased the level of toxic metals (Rashid *et al.,* 2012; Zakir *et al.,* 2013; Hasan *et al.,* 2014; Islam *et al.,* 2015), fecal coliform, and other harmful bacteria (Zuthi *et al*., 2009; Sarker *et al*., 2019), which has a variety of adverse health effects (Schwarzenbach *et al*., 2010; WHO, 2012; Alidadi *et al*., 2019; Lin *et al*., 2022; Sing *et al*., 2022). Usage of contaminated water from both safe and unsafe sources causes various waterborne diseases like diarrhea, cholera, jaundice, typhoid, hepatitis, etc. (Rahman, 2016). It is responsible for approximately 3.5 million deaths annually (World Vision, 2021), making it one of the leading causes of global mortality (Berman, 2009). Additionally, according to estimates from WHO and UNICEF in 2000, as well as Rosegrant and Cai (2002), poor drinking water contributes to an estimated four billion instances of diarrhea each year, which results in two million fatalities. The lower income group suffers the most since they cannot afford safe drinking water for an active and healthy life (Rahman and Jahan, 2003).

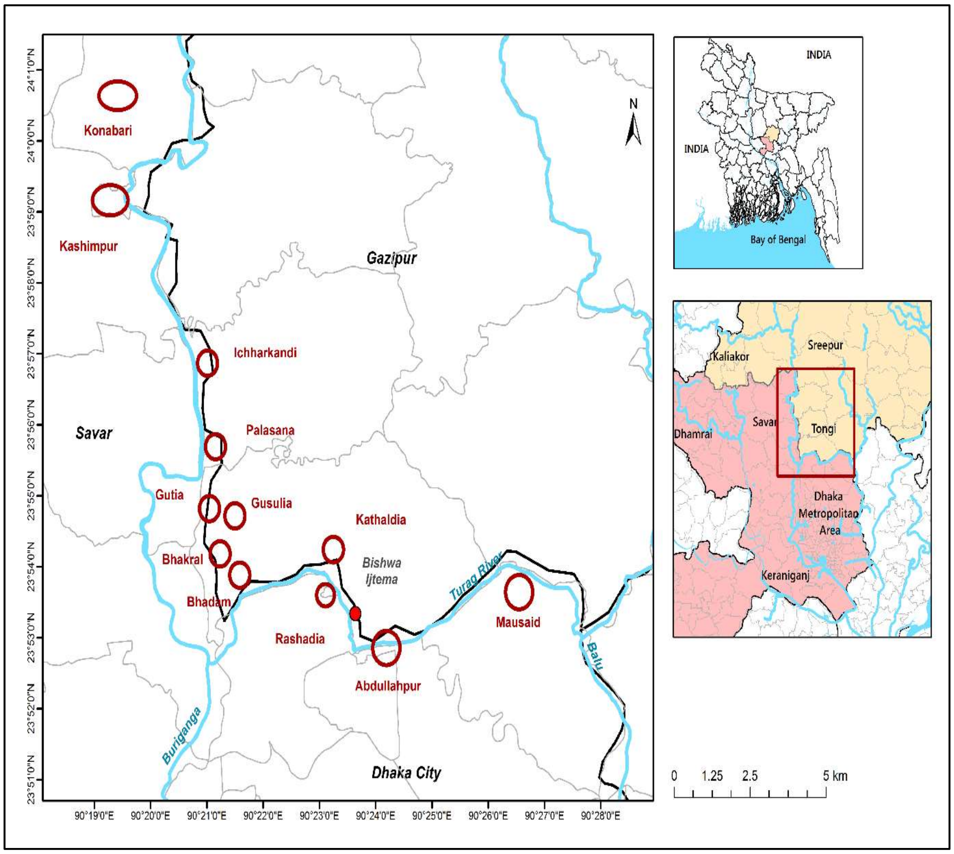
The Seventh Five Year Plan (SFYP, 2016–2030) of the Government of Bangladesh calls for the availability and accessibility of safe drinking water to all rural and urban residents, synonymous with the goal (six) of the United Nations' Sustainable Development Goals (SDGs, 2016–2030). The current research, therefore, can benefit policymakers by highlighting the significance of safe water for public health and suggesting strategies for the sustainable supply and management of water for those who lack access to it. However, the present study entails understanding **a)** available water sources for drinking and domestic usage and **b)** the differential impacts of water quality on the health of the dependent communities.

Methods

Selection of study area and population: The Turag is a prominent river in Bangladesh that is only 7.9 km away from Dhaka (Haque, 2018). This river is of paramount importance as the main drainage channel of Dhaka city (Salam and Alam, 2014) and is of great importance from an economic point of view (Ahmed and Bodrud-Doza, 2013). The Turag is also home to a substantial amount of human activity ranging from navigation (Rahman *et al*., 2013), fishing (Baki *et al*., 2015), agriculture (World Bank, 2007), and in many instances, as a source of water for domestic purposes (Bhuiyan *et al*., 2011). Considering the sources of drinking water and the proportion of households adjacent to the Turag River, twelve areas, namely Konabari, Kashimpur, Ichharkandi, Palasana, Gutia, Gusulia, Bhakral, Bhadam, Rashadia, Kathaldia, Abdullahpur, and Mausaid (Map 1) were selected for the survey. Before selecting these survey areas, several reconnaissance visits were made to familiarize the area with potential samples and identify the diverse water security challenges in different areas. The visits also enabled us to design the survey questionnaire and sampling strategy.

The study follows a probability sampling technique in drawing the sample households, the unit of analysis. The study population covered the households living within half a kilometer of the banks or canals of the Turag River with the samples from the newly growing industrial zones. Households living near a river within a given distance having the chance of being exposed to the river were treated as the target population. Similarly, the households residing a short distance from the river and less likely to be exposed to the river were treated as the control population.

Data collection and analysis: To capture the intra-household water resource usage, the survey focused on individual household data. A total of 1826 households were surveyed purposively from December 2017 to February 2018 across the selected twelve sites along the Turag River area. The data was collected using a mobile data collection software called "Organizational Network Analysis (ONA)." To do this, the questionnaires have been transformed into an online version and made suitable for ONA. The household head or his/her spouse was the target respondent. A standard semi-structured survey questionnaire was developed and applied to collect data from the respondents. The questionnaire was pre-tested through eight interviews during scoping and revised following the pre-test. The questionnaire was in English, but interviews were conducted in the local language, Bangla.



Map 1: Study sites along the Turag river area (Source: REACH, Oxford)

Likewise, six FGDs comprised 7 to 8 participants, and twelve KIIs were conducted concurrently at six selected study sites (Kashimpur, Konabari, Bhadam, Bhakral, Abdullahpur, Mausaid). A thematic checklist was developed to collect information through focus groups and key informant interviews. Locally knowledgeable persons, political leaders, doctors, local volunteers, members of civil societies, government officials, and non-government officials participated in the KII. Local medical institutes were also visited to understand the extent of waterborne diseases in the survey areas. In addition, we carefully analyzed over seventy (70) scientific articles, conference and workshop proceedings, national and international reports, survey data published by the government and other respected organizations (BBS, DoE, BNDWQS, SVRS, HIES, etc.), books, online citations, and other relevant materials. This helped us understand the current state of groundwater and the Turag River, the quality of available water sources, and the sources of contamination.

The study employs statistical and descriptive techniques to analyze the survey data. Any errors in spelling, grammar, or punctuation have been corrected. The primary level of analysis was done using ONA, and further statistical analysis was done using the Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics were utilized to explore the general characteristics of the study population. Spearman's rho (*ρ's*) values were obtained to investigate the relationship between the dependent variable (disease incidence) and independent variables (water sources) of the study. The statistical significance level was set at 97.5% for both ends (equivalent to 95% significance level). Then again, to examine how communities become infected with diseases linked to water usage, disease ecology theory was used to understand the process.

Results

Respondents' characteristics: Among the 7134 population in 1826 households surveyed, 50.1 percent (n=3573) were male, and 49.9 percent (n=3561) were female. The average household size is 4.0, slightly smaller than the national average urban household size of 4.4 (BBS, 2011). Out of all households, 91.4 percent are headed by males (n=1669) and only 8.6 percent by females (n=157), which is 84.1 percent of male-headed and 15.9 percent of female-headed households in Dhaka according to Bangladesh Sample Vital Statistics (2020). The highest concentration of the population exists in the age group of 16-25, with male and female percentages of 20.6 and 25.2, respectively. Age group ranges from 26-35 and 6-15, securing 2nd and 3rd highest rank (20.1% and 19.4%, respectively). The percentage of the population aged 0-5 is 7.5 percent, and the population aged 66 and over is 2.3 percent. Of the surveyed respondents, 28.5 percent (n=928) were recorded as illiterate, 25.8 percent (n=923) completed primary school, and only 3.3 percent (n=160) had a bachelor's or higher degree. The surveyed household members were found to work in garment factories (10.8%), in business (7.5%), as skilled laborers (2.7%), in non-government services (1.5%), in farming (2.8%), in fishing (1.2%), etc. occupations.

Sources of water for drinking and domestic purposes: Fig. 1 shows that the motor tubewell (73.8%) was the primary source of water supply among the studied communities, followed by piped water into the dwelling (4.5%), piped water into the yard (16.7%), deep and shallow tubewell water (2.6%), and tap water (2.1%). Communities were also found to depend on vented water sources (bottled water/tanker trucks/cart tanks) (0.4%) when other alternative sources were unavailable. Other water sources (0.7%) include neighbors' water sources, compressor and submersible pumps, brickfields, etc. Also, a certain percentage (2.8%) had been recorded using open sources such as rivers, lakes, ponds, and rainwater for drinking purposes. As this group has no fixed sources, they alternatively collect drinking water from electric/motor tube wells owned by other households (2.2%), deep and shallow tube wells (0.3%), public standpoints (0.1%), ponds (0.1%,), etc. based on its availability and whenever they get accessed to it.

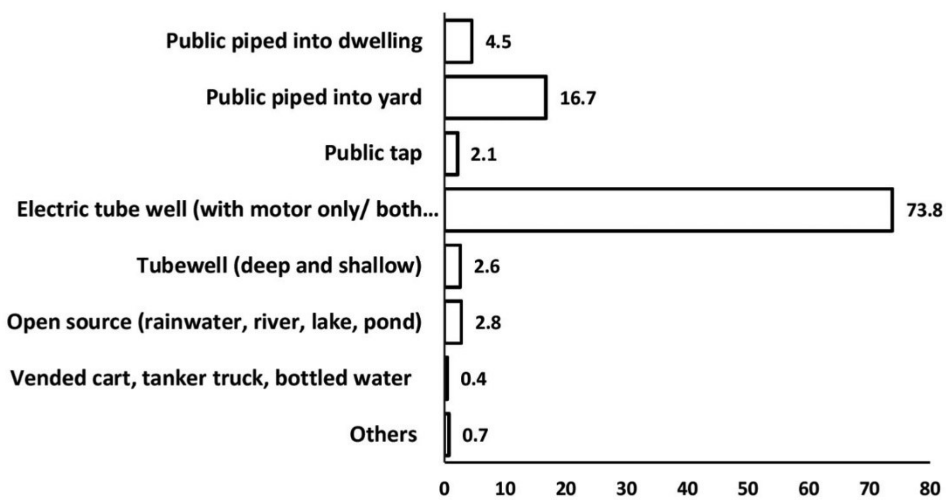


Fig. 1. Sources of drinking water (%) identified in the studied area.

The household survey also shows that communities' primary water sources for domestic uses come from motorized tubewell (69.1%), piped water (19.8%), tap water (2.1%), and deep and shallow tubewell water (2.3%). A noticeable percentage of people (21.1%) were also found to depend on unsafe sources like rivers, canals, ponds, lakes, and rainwater for cooking, washing (vegetables, clothes, dishes, etc.), bathing, and hygiene purposes.

Respondents also revealed that the water they drank is unsafe (4.2%); their primary justifications for this belief include the presence of yellow crust in the storage pot locally identified as iron (2.9%) and various unwanted components (1.3%), with terrible odor and taste (1.0%). Also, when asked about the condition of the water they use for domestic purposes, 6.9 percent (n=126) of respondents reported that the water they use is dirty. Interestingly, these people found supply or ground sources, especially motor tubewell water, much more polluted than the Turag River water they depend on for various domestic uses (FGDs).

Disease incidence among studied communities

Disease prevalence among the studied community over the past year: The surveyed community suffered (27.5%, n=1968; N=7134) from various diseases in the past year; gastric ulcers and stomach pain ranked the highest (36.6%). Diseases like skin problems (12.6%); dysentery, diarrhea (12.5%); chikungunya, and dengue (11.1%); jaundice (9.2%); typhoid (6.0%); tuberculosis, pneumonia (5.4%); cholera (0.8%), etc. (Fig. 2) were also well documented. Illnesses such as body pain, back pain, respiratory problems, gynecological problems, tonsils, and fever were most frequent under other categories and represented 30.1 percent of the total count. Gender-wise illness shows no significant variation, although the females were affected more (64.8%) than males (59.5%). Both males (16.6%) and females (20%) were documented to suffer from gastric ulcers at a higher percentage than other diseases recorded. They may stem from irregular eating habits and water consumption from unsafe sources. Overall, focus group discussions and key informant interviews revealed that women continue to have higher rates of cholera, dysentery, and skin issues than males due to their considerably higher engagement in water-related activities.

Area-wise (Table 1), the rate of unsafe water intake was the highest among the communities living in Ichharkandi (1.4%) and Palasana (1.1%). However, disease incidence in those areas remained lower than in other areas regarding the total population surveyed (13.1% in Ichharkandi and 15.8% in Palasana). Among other areas, the second-highest surveyed population was documented in Kathaldia (n=914; 12.8%), though disease occurrence remained the lowest (14.8%). Drinking water sources in this community were piped connections (7.2%) and motorized tube wells (4.9%), and no interaction with unsafe water was documented.

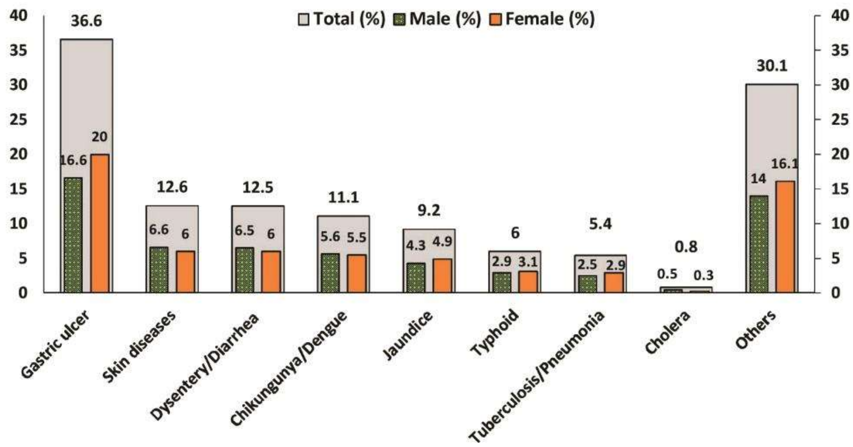


Fig. 2. Gendered variations (%) of disease occurrence.

Table 1. Area-wise disease occurrence and dependent sources of water.

Area	Population		Disease		Disease incidence (%)	Sources of drinking water			
						Supply/ groundwater		Open water sources	
	n	%	n	%		n	%	n	%
Konabari	1040	14.6	400	5.6	38.5	248	13.7	0	0.0
Kasimpur	786	11.0	306	4.3	38.9	204	11.3	1	0.1
Ichharkandi	582	8.2	76	1.1	***13.1***	163	9.0	***25***	***1.4***
Palasana	411	5.8	65	0.9	***15.8***	109	6.0	***21***	***1.1***
Gutia	435	6.1	78	1.1	17.9	104	5.8	0	0.0
Gusulia	279	3.9	60	0.8	21.5	65	3.6	1	0.1
Bhakral	362	5.1	132	1.9	36.5	85	4.7	0	0.0
Bhadam	590	8.3	171	2.4	29.0	197	10.8	0	0.0
Kathaldia	***914***	***12.8***	***135***	***1.9***	***14.8***	***222***	***12.1***	***0***	***0.0***
Rashadia	270	3.8	145	2.0	53.7	69	3.9	0	0.0
Abdullahpur	832	11.7	533	7.5	64.1	221	12.1	3	0.2
Mausaid	633	8.9	344	4.8	54.3	140	7.7	0	0.0
Total	**7134**	**100**	**2445***	**34.3**	**34.3**	**1827***	**100.2**	**51***	**2.8**

*M.R.; Source: H.H. Survey, 2017-18; Supply/groundwater: motorized tubewell, pipe water, tap water, deep and shallow tubewell, etc.; Open water sources: river, lake, pond, rainwater, etc.

The FGD participants identified skin diseases, dysentery, diarrhea, dengue, chikungunya, respiratory problems, typhoid, cholera, fever, jaundice, and gastric as their greatest health risks (Table 2). Women are more likely to engage in water-related activities and work with dirty Turag River water for domestic chores, making them more susceptible to developing skin problems (FGDs and KIIs). Itching in intimate parts was also an issue for women as they were contingent on polluted water for bathing and toileting (FGDs and KIIs).

Table 2: Health profile of studied communities based on FGDs and KIIs

The greatest health risk identified by the community	Score	Rank
Skin problem/itching	11	1
Stomach upset/dysentery/diarrhea	10	2
Respiratory problem/asthma	4	3
Dengue/chikungunya	4	3
Jaundice	3	4
Typhoid	2	5
Cholera	2	5
Fever	2	5
Gastric	1	6
Kidney problems	1	6
Body swelling	1	6

Source: FGDs and KIIs, 2018

Spearman's rho analysis (ρ's) results, as presented in Table 3, show that among all diseases, dysentery shows significant relation with piped water into the dwelling ($p<0.016$); cholera with pond water ($p<0.001$); typhoid with rainwater ($p<0.005$); jaundice with deep tubewell ($p<0.009$) and vended water ($p<0.017$); gastric, ulcers with piped water into the dwelling ($p<0.002$), piped water into the yard ($p<0.032$), river water ($p<0.002$) and pond water ($p<0.018$). Chikungunya, dengue, and malaria show significant relation with piped water into the dwelling ($p<0.001$), piped water into the yard ($p<0.001$), shallow tubewell ($p<0.001$), and motor tubewell water ($p<0.003$); diseases like tuberculosis, pneumonia found significantly linked with river and canal water ($p<0.001$).

Table 3. Spearman's rho (ρ's) test of association between disease incidence and water sources

Spearman's rho (ρ's) test of association	p-value
Dysentery/ Diarrhoea ~ Piped water into the dwelling	0.016**
Cholera ~ Pond	0.001*
Typhoid ~ Rainwater	0.005*
Jaundice ~ Deep tubewell	0.009*
Jaundice ~ Vended truck	0.017**
Gastric/ulcers ~ Piped water into the dwelling	0.002*
Gastric/ulcers ~ Piped water into the yard	0.032**
Gastric/ulcers ~ River/canal	0.002*
Gastric/ulcers ~ Pond	0.018**
Chikungunya/Dengue ~ Piped water into the dwelling	0.001*
Chikungunya/Dengue ~ Piped water into the yard	0.001*
Chikungunya/Dengue ~ Shallow tubewell	0.001*
Chikungunya/Dengue ~ Motor tubewell	0.003*
Tuberculosis/ Pneumonia ~ River/Canal	0.001*

(Each value on the table represents the test statistics value at a 95% significance level). **significant at 0.05, *significant at 0.01

Case of malnutrition among the studied communities: Collecting and analyzing malnutrition data is essential because it increases the susceptibility to disease occurrence. Of the total people surveyed (n=7134), 18.2 percent (n=1298) were documented malnourished, and more females (51.3%, n=666) were found malnourished than males (48.7%, n=632). It is also found that malnutrition remains highest among the most active age groups, i.e., 16-25 yr (20%), 6-15 yr (18.2%), 26-36 yr (16.1%), 36-45 yr (12.9%), and 46-55 yr (10.3%) while it was lowest among infant (>5 yr) and elderly (<66 yr) group.

Discussion

This section is further discussed under two main parts. The first part provides a general discussion of findings to support the objectives set. The second part attempts to fit the study findings on the adopted theory.

Linking disease occurrence with sources of water: Though in the present study, motorized tube wells, deep and shallow tube wells, and piped and tap water supplies were documented as the primary water sources, communities were also found to depend on rivers, ponds, and other sources of doubtful water quality for household use (21.1%) as well as for drinking (2.8%) due to lack of sufficient and easily accessible water supply. According to the BBS (2017) and SVRS (2019) reports, tap water accounts for 23.7 and 27.5 percent of the primary drinking water sources in urban areas, respectively, while tube wells make up 60.2 and 67.1 percent. Additionally, the SVRS (2019) report found that 1.8 percent of Bangladesh's population (about four million people) depended on unsafe sources (ponds, rivers, streams, or unprotected wells, springs, etc.), which corresponds to 3 percent of the country's overall population according to the World Bank (2018) report. In a similar work, Jinnah's (2007) research shows that 3.8 percent of Bangladesh's slum dwellers use rivers, ponds, lakes, and canals as drinking water sources. As revealed in the current study (FGDs and KIIs), interacting with unprotected sources, in this case, the Turag River water for cooking, washing, bathing, and other domestic uses results in health issues like dysentery, skin problems, respiratory problems, etc. among the examined people (Table 2).

The presence of yellow crust or iron in supply water has been confirmed and labeled as unsafe to drink by the studied community (2.9%). According to BNDWQS (2011), the average concentration of iron (Fe) present in the shallow (2.65 mg/L) and deep tubewell (1.37 mg/L) water throughout the country exceeded DOE (1997) Bangladesh standards of 0.3 mg/L and 1.0 mg/L, respectively. Consuming excessive iron has the potential to cause multiple organ dysfunction such as liver fibrosis (Heming *et al.,* 2011), diabetes (Swaminathan *et al.,* 2007; Heming *et al.,* 2011), lung and heart disease (Milman *et al.,* 2001), etc. as reported in case of the studied population. Simultaneously, unpleasant tastes or odors pointed out by the studied communities (1.0%) in microbiologically safe water supplies may act as a deterrent to the use of safe sources, exposing them to unprotected water sources, in this case, the Turag River, and thereby increasing the people health risks (Hunter *et al.,* 2010). As reported by the World Bank (2018), *E. coli* is found in 80 percent of private piped water taps across the country, a number that is comparable to water taken from ponds. MICS (2019) report verified that 84.1 percent of households in Dhaka use water sources tainted with *E. coli*. Moreover, the work of More (2017) demonstrates that in Bangladesh, very high *E. coli* risk levels ($p>100$ CFU/100 mL) were found in 46.3 percent of piped water into dwellings and 3.6 percent of tube wells. The presence of microorganisms in the tubewell water of Bangladesh is also confirmed by the work of Hoque *et al.* (2006), Rahman *et al.* (2014), Kabir *et al*. (2016), Sarker *et al.* (2019), etc. Thus, disease incidence among the studied communities might result from microbial components and other harmful contaminants in their relied water sources.

Although in the present study, most of the disease occurrence shows significant relations with safe water sources, diseases like cholera, typhoid, and tuberculosis depend entirely on open sources such as ponds (<0.001), rain (0.005), river water (< 0.001), etc. As shown in Table 3, diarrhea and dysentery are associated with piped water. Payment *et al*. (1997) also discovered tap water to be a pivotal contributor to these diseases. Worldwide, cholera continues to be a serious public health issue that can result in up to 4.0 million cases and 95,000 fatalities each year (Ali *et al*., 2015). However, the prevalence of cholera in the current study is still low (0.8%; Fig. 2) but shows a strong association with pond water ($p>0.001$; Table 3), which is consistent with Sheppard's (1995) findings that cholera transmission is associated with surface water. Additionally, according to Hashizume *et al.* (2008), the chance of acquiring cholera is raised due to drinking tubewell water and visiting unhygienic toilets. Also, practices like bathing, washing utensils and clothes, washing mouth in pond water, and occasionally drinking are significantly associated with this type of illness (Mukherjee *et al.,* 2011). The work of Parvin *et al.* (2022) indicates that rain influences typhoid occurrence by increasing fecal contamination, supported by the present study findings where the occurrence of typhoid is found to be significantly linked with rainwater (Table 3). However, some studies (Corner *et al.,* 2013; Dewan *et al.,* 2013) show that communities living near large bodies of water (lakes and river networks) are particularly susceptible to typhoid outbreaks, which is true in the case of the present study. Jaundice, which was found to be significantly associated with tube wells ($p<0.009$) and carts water ($p<0.017$) in the studied communities, is brought in by a high concentration of coliforms and gram-negative bacteria. Jaundice is also believed to be associated with water deficits in all megacities (Kumar *et al.,* 2022), sewage water infiltration in the water supply, and improper water handling practices (Rathour *et al.,* 2022). The association of jaundice with cart water (vented truck) might be because it was in short supply from regular sources and handled unhygienically by seller groups. On the other hand, the possible explanation for the connection of jaundice with tubewell water in this study is likely due to its contamination with sewage lines or old, rusted pipelines lying close to sewer lines. According to HIES (2016), gastric ulcers among urban dwellers (20.3%) are most common; in the present study, gastric ulcers were found linked to both safe (piped water into dwelling and yard) and unsafe (river and pond) sources (Table 3). Nonetheless, the increased prevalence of stomach ulcers in surveyed communities might result from an irregular diet, drinking less water, and stress-related factors (Shamsuddeen *et al.,* 2009).

Dengue and chikungunya fever are rapidly spreading viral diseases that are very common among the studied population (Fig. 2). Stagnant water in urban areas and poor waste management create potential breeding grounds for mosquitoes and other disease-carrying vectors, increasing the risk of dengue and chikungunya fever. They spread because the vectors breed in water bodies close to where the surveyed people are living. Though not regarded as a water-related illness, respiratory problems (tuberculosis, pneumonia) in the surveyed communities are found in a percentage of 5.4, corresponding to 9.4 percent of the population in metropolitan areas (BBS, 2017). While skin problems are quite prevalent among the examined populations (12.6%), their prevalence is still lower (2.4% in the metropolitan area), according to the BBS report (2017). Many interviewees (FGDs) affirmed having skin issues because of their engagement in water-related household activities and regular exposure to river water, in line with similar findings from the works of Halder and Islam (2015), Hanif *et al.* (2020), etc. This type of skin problem occurs when hazardous substances accumulate in the body because of the disposal of textile dyes in the surrounding river (Ahmed *et al.,* 2005) and contaminated groundwater through infiltration (Nishat *et al*., 2001; Motlagh, 2013; Mohiuddin, 2019). Another prevalent condition in the populations under study is malnutrition (18.2%). Malnutrition can also aggravate the risks of other diseases caused by water pollution. Prüss-Üstün *et al*. (2008) claimed that consuming contaminated water and exercising poor hygiene might lead to persistent diarrhea and other infectious diseases, ultimately contributing to malnutrition.

Implications of adopted theory into study findings: The adopted theory, however, suggests that the interaction of three factors- habitat, population, and behavior, often affects disease prevalence (Meade and Emch, 2010). Hence, the study aims to comprehend how host-pathogen interactions in urban environments with various types of water sources affect the occurrence and spread of diseases.

The adopted disease ecology framework views the studied *communities* as the potential hosts of the disease, where the people's susceptibility or resistance to diseases is influenced by their age, sex, modalities of work, etc. Females are revealed to be more susceptible to some illnesses than males due to their differing roles in domestic tasks involving water. Alternatively, the most active age group (26-35 yr) of the studied communities, primarily in charge of water-related household activities, continues to have the highest rate (27.6%) of disease occurrence. The water resources (Fig. 1) on which the communities under study rely for their daily water needs and the quality, availability, and cost of these services are all considered *habitats.* The study communities' disease occurrence has remained relatively high and linked with supplied and surface water (Table 3). Water from these sources may contain harmful substances or microbes, exposing the community to diseases like diarrhea, dysentery, cholera, jaundice, typhoid, etc. Disease ecology theory also recognizes the role of human *behavior* and water-related activities in disease transmission. Human *behavior*, which includes household-level hygiene practices, water collection, water storage, water handling practices, waste disposal practices, etc., can contaminate water and cause the spread of diseases that are transmitted through water. However, further research and analysis require a comprehensive understanding of disease ecology and its relationship with urban water sources.

Conclusion

Water and health are intricately interconnected, and this exploratory study from urban Bangladesh sheds light on the challenges communities face in accessing clean and safe water. Safe water supplies free from microbes, parasites, and chemical or physical contaminants are essential to sustainably growing cities and citizens' well-being, as ignorance of extending water services to millions of people plays a crucial role in underpinning health. By prioritizing easy accessibility and ensuring its quality, we can pave the way toward healthier and more sustainable urban communities in Bangladesh and beyond. An expanded water intervention program by the Government and NGOs to ensure a satisfactory level of safe water supply can effectively ensure good health. However, future studies are urged to focus on aspects other than water quality, such as household-level sanitation and hygiene practices, the quantity of water for drinking and household uses, water storage and treatment practices to acquire a greater knowledge of how diseases arise, like the issues addressed in Goal 6 of Agenda 2030 of drinking water, sanitation, and hygiene.

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