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ABSTRACT

Handwashing is one of the vital public health measures. It helps to prevent the spread of the COVID-19 pandemic. However, water overuse during hand scrubbing with soap keeping the tap on may put enormous pressure on the already overstretched groundwater resources and households' economic well-being. Therefore, this study aimed to determine the overuse of water while scrubbing hands with soap for handwashing when the tap is on amid the COVID-19 pandemic in Bangladesh. Sociodemographic data were collected using a web-based survey tool among 1980 participants and an experiment was conducted among 126 participants to estimate the overuse of water during hand scrubbing while the tap is on. A total of 80% of the participants washed their hands regularly after returning home from outside. About 57.27% of participants did not turn off their tap throughout the handwashing process. A single participant, who kept his tap on throughout the handwashing process, overused approximately 1.7 L of water per handwash and 14.9 L of water per day. Hand scrubbing with soap keeping the tap on, raised the overuse of water 13-fold during this pandemic compared to the non-pandemic situation which cost an extra 224.95 BDT (2.65$) per day for 1980 participants. Minimize the speed of tap, using automatic taps, and using taps operated by legs might be an effective solution to reduce the water overuse. Furthermore, behavioral change interventions are needed to aware people turn off the tap during hand scrubbing with soap.

1. Introduction

Hand hygiene is often considered synonymous with handwashing and it is the most important factor in preventing nosocomial infections by preventing contact and fecal-oral transmission of pathogens (Boyce and Pittet, 2002; Widmer, 2000). Hand hygiene is an important public health measure (Burton et al., 2011; Tao et al., 2013) and it has long been recognized to be a convenient, effective, and also cost-effective means of preventing infectious diseases (Tao et al., 2013). During the COVID-19 pandemic, frequent handwashing with soap and water was

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recommended as one of the most effective measures to reduce the spread of infection (CDC, 2020; UNICEF, 2020; WHO, 2020a). In addition to that, WHO and UNICEF also recommended switching the faucet/tap off while lathering hands with soap and scrubbing for at least 20 s to prevent water loss (WHO, 2020b).

Many countries around the world, including Bangladesh, utilize groundwater as the main source of drinking water and daily domestic activities. Evidence suggests that the frequency of handwashing increased during a pandemic situation (Park et al., 2010). The outbreak of Ebola in West Africa in 2014–16 has also raised the demand for clean water for prevention and treatment (Conversation, 2020). Therefore, the frequency of handwashing has also been reported to be increased during the co-current COVID-19 pandemic (Amegah, 2020; Roshan et al., 2020). The water demand raised by 20–25% in India during this COVID-19 pandemic due to keeping the tap open during handwashing (Rohilla, 2020). Besides, a water sector official in Jordan, recently claimed that water demand has increased by 40% after the government ordered people to stay home as part of a nationwide curfew (Conversation, 2020).

This increase in demand will bring tremendous pressure on overstretched groundwater resources to fill existing shortages in the water supply in a resource-constrained country like Bangladesh (Hedrick, 2018; van der Voorn et al., 2020). In Dhaka, the capital of Bangladesh with over 21 million population, the trend of water-level change is mostly consistent with the pace and extent of groundwater extraction (Hoque et al., 2007). Over the past 50 years, the abstraction of groundwater caused water levels to decline by more than 60 m, and these levels continue to decrease at a rate of more than 3 m per year in Dhaka city (Hoque et al., 2007; Khan et al., 2016). In these urban settings, rapid population growth may worsen the problems with groundwater depletion (UN, 2014; van der Voorn et al., 2020; UNICEF, 2020. The current practice of groundwater abstraction and use in other areas of the country may make the groundwater resources unsustainable (Mojid et al., 2019). This situation will be further worsened in the country in summer when sources of water supply run dry. Therefore, the overuse of water due to excess water flow, especially keeping the tap on while hand scrubbing for handwashing is a serious issue (Sayeed et al., 2020). However, there is no previous study to evaluate the overuse of water because of open tap while hand scrubbing with soap during the practice of handwashing. Therefore, this study aimed to estimate the overuse of water during scrubbing hands with soap for handwashing with running taps amid the COVID-19 pandemic in Bangladesh with an emphasis on quantifying the potential overuse of groundwater.

2. Methods

2.1. Setting and participants

A prospective cross-sectional web-based survey was conducted among the general population of Bangladesh to assess handwashing practices from May 11th to June 7th, 2020. As a community-based face to face survey was not feasible during this COVID-19 pandemic situation, data was collected through online from all divisions of Bangladesh. The authors distributed the survey link in all divisions of Bangladesh via social media among rural and urban people. The Snowball sampling method was used to recruit the participants (Kirchherr and Charles, 2018). Snowball sampling is defined as a non-probability sampling technique in which the samples have traits that are rare to find. This is a sampling technique, in which existing subjects provide referrals to recruit samples required for a research study. The chain referral process allows the researcher to reach populations that are difficult to sample when using other sampling methods. In our study there were 7 people who initially sampled to start the "snow ball". Then they shared the link among Bangladeshi resident aged more than 18 (Kirchherr and Charles, 2018). To improve the participation rate, reminder requests were sent through social media at 1-week intervals for a total of three times. The survey questionnaire was sent to more than 2500 participants and 1980 of them from all the divisions of the country aged between 18 and 67 years completed the questionnaire. Eligibility criteria included the ability to read Bangla, residence in Bangladesh during the pandemic, and having access to the internet.

2.2. Data collection

A survey tool was developed considering the regular pattern of handwashing practice and facility during the COVID-19 pandemic. The questionnaire survey consisted of 14 close-ended questions of 4–5 min duration (Table 1). Sociodemographic data were collected on age, gender, educational status, location of residence. Besides, the survey included questions on the frequency of handwashing, duration of lathering and scrubbing hands with soap, whether they keep their tap on or off during the lathering and scrubbing process.

The survey tool was piloted with a small online user group to test its clarity and consistency. The survey included a short overview of the study context, purpose, procedures, confidentiality agreement, and consent. This study complied with the most recent revision of the Helsinki Declaration (Williams, 2008) and followed the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines (Eysenbach, 2004). Descriptive statistics were performed to define the fundamental characteristics of the data in the participants.

2.3. Experimental design

The experiment was designed based on the method described by Green Venture (2007), and used in a previous study for determining the flow rate of water in China (Lu and Smout, 2008). The objective of the experiment was to estimate the volume of water drained during that time. We invited 1134 participants (57.27% of total participants) who did not turn off their tap during handwashing for voluntary participation in the study. Among them, a total of 126 participants (6.36% of total participants) agreed and participated in the experiment session from their house, and each used 1 domicile handwashing tap. The participants' inclusion criteria for the experiment of determining flow rate was to have the experimental tools such as stopwatch, milliliter jug, etc. All the participant who took part in this experiment were trained through online video conference. We divided them into 14 groups, with nine participants in each group during the training session. Each participant used one tap from his/her home and took part in 3 experiments at three different speeds of the tap. For the better measurement of flow rate a total of 378 experiments were conducted setting the tap at minimum (average = 39.41 mL/s; 126 experiments), medium (average = 84.16 mL/s; 126 experiments), and maximum speed (average = 161.33 mL/s; 126 experiments) arbitrarily. The water flow rate is the volume of water (mL) per unit time (s) that flows through the tap. Then water was collected in a water bottle marked for milliliter measurement. The required time to fill 1 L of water for each experiment was recorded and noted, then the overuse of water was calculated for 17.95 s (Table 2).

2.4. Data analysis

The data collected was encoded and entered into a computer using Microsoft Excel 2016 version and exported to SPSS. All statistical analyses were performed using the SPSS Windows version 24 (IBM SPSS Statistics, New York, United States). Descriptive statistics such as frequency, percentages, mean, and standard deviation were calculated and presented in the tables.

2.5. Ethics

The research protocol was reviewed and approved by the Research Ethical Committee (REC) of the Department of Food Microbiology, Patuakhali Science and Technology University, Bangladesh (Approval

Table 1
Demographic characteristic and handwashing status of the participants.

Variables	N	%	95% CI
Gender			
Female	882	44.55	32.1–38.1
Male	1098	55.45	62.1–67.6
Education			
No schooling	112	5.65	4.5–6.3
Primary	178	8.98	7.0–9.77
SSC[a]	286	14.44	12.3–16.1
HSC[b]	516	26.06	24.6–27.4
Graduate	692	34.94	32.4–36.8
Post-graduate or higher	196	9.89	8.1–10.4
Occupation			
Business	206	10.40	8.7–12.1
Employee	572	28.88	26.9–29.7
Health professional	104	5.25	4.9–6.2
Housewife	134	6.76	5.6–7.2
Student	506	25.55	24.2–26.3
Un-employed	372	18.78	17.5–19.3
Others	86	4.34	3.1–5.2
Residence			
Urban	1466	74.04	70.2–79.3
Rural	514	25.96	21.3–28.9
Source of domiciliary water			
Own water source	775	39.14	36.01–43.9
Municipality	1205	60.86	57.4–64.7
Handwashing after returning home from outside			
No	32	1.6	1.0–2.3
Regularly	1542	77.9	75.5–80.3
Sometimes	208	10.5	8.7–12.3
Use hand sanitizer	198	10.0	8.4–11.7
Handwashing after sneezing			
No	294	14.8	12.7–17.0
Regularly	734	37.1	34.0–40.1
Sometimes	618	31.2	28.5–34.1
Use hand sanitizer	334	16.9	14.8–19.1
Effect of COVID-19 on handwashing			
Wash hand same as before pandemic	32	1.6	1.0–2.3
Wash hand more than before pandemic	1750	88.4	85.6–90.2
Wash hand less than before pandemic	0	0	0
Not applicable	198	10.0	8.4–11.7
Handwashing facility			
Tube well water	164	8.3	6.8–10.0
Tap water	1646	83.1	80.7–85.4
Stored water (Balti/Mug)	86	4.3	3.1–5.7
Pond water	36	1.8	1.1–2.5
Others	48	2.4	1.7–3.2
Types of tap			
Automatic	12	0.6	0.36–0.78
Do not use tap	334	17.07	15.1–19.3
Manual	1634	82.52	80.2–85.5
Turn off tap			
Yes	512	25.85	23.4–28.6
No	1134	57.27	54.4–60.2
Not applicable	334	17.07	15.1–19.3
Variables	**N**	**Mean**	**SD**
Number of handwash per day before COVID-19	1980	2.89	0.23
Number of handwash per day during COVID-19	1980	8.93	5.86
Duration of hand scrubbing with soap during COVID-19	1980	17.73	8.84
Duration of hand scrubbing with soap before COVID-19	1980	4.23	1.87
Number of handwash per day before COVID-19 who keep the tap on	1134	2.79	0.22
Number of handwash per day during COVID-19 who keep the tap on	1134	8.73	5.78
Duration of hand scrubbing with soap during COVID-19 who keep the tap on	1134	17.95	8.91
Duration of hand scrubbing with soap before COVID-19 who keep the tap on	1134	4.39	1.89

[a] SSC= Secondary School Certificate.
[b] HSC= Higher Secondary Certificate.

Table-2
Overuse of water due to keeping the tap on during lathering and scrubbing of hands with soap for handwashing.

Speed of the taps	Total no. of taps	Average overuse of water[a] per second (mL ± SD)	Average overuse of water[a] in 17.95 s[b] during COVID-19 pandemic (mL ± SD)	Average overuse of water[a] in 4.39 s[c] before COVID-19 pandemic (mL ± SD)
Minimum Speed	126	39.410 ± 17.178	707.417 ± 308.322	173.00 ± 13.56
Medium Speed	126	84.166 ± 34.738	1510.785 ± 623.556	369.46 ± 37.36
Maximum Speed	126	161.339 ± 51.591	2896.031 ± 926.063	708.27 ± 37.36
Average Speed	126	94.972 ± 34.502	1704.744 ± 619.313	416.92 ± 37.36

[a] Keep the tap on during lathering hand with soap and scrubbing.
[b] Average duration of lathering hand with soap and scrubbing among the participants who usually keep their tap on throughout the handwashing process during COVID-19.
[c] Average duration of lathering hand with soap and scrubbing among the participants who usually keep their tap on throughout the handwashing process before COVID-19.

No: FMB:May 29, 2020:06).

3. Results and discussion

3.1. Demographic information

The characteristics of the participants is presenting in Table 1. Of the 1980 participants, 55.45% were male, 44.55% were female. 28.88% of the participant were employees, 25.55% were students, and 18.78 were unemployed. 34.95% of the participants completed their graduation and 5.65% had no schooling experience. Although most of the respondents were from the Dhaka division (19.09%), also respondents from all 8 divisions of the country participated in the study (Fig. 1). The majority of the participants were from urban areas (74.04%) and use municipal water for domiciliary use (60.86%).

3.2. Handwashing practice during COVID-19 pandemic

The present study found that 77.9% of the participants practiced regular handwashing after returning home from outside during the

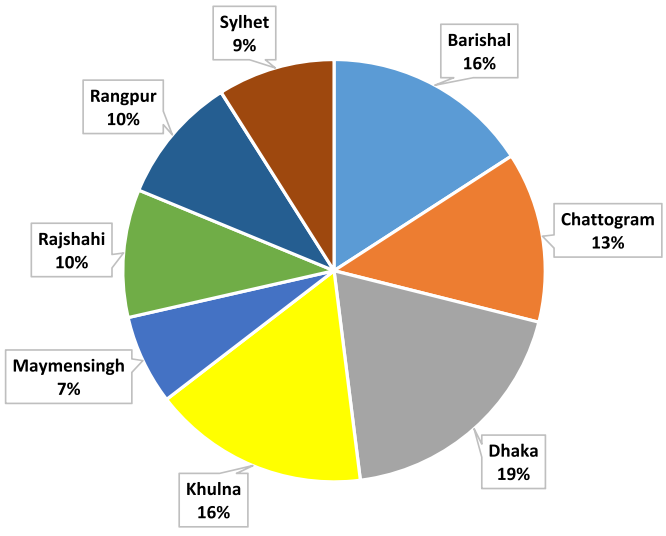

Fig. 1. Distribution of the 1980 participants and the response rates from the 8 divisions of Bangladesh.

pandemic, which is lower compared to the others study in Bangladesh (Haque et al., 2020; Kundu et al., 2020; Wadood et al., 2020). This lower rate of handwashing practice after returning home from outside could be because of the less movement outside of home due to restrictions imposed by the government for COVID-19 pandemic during the study period. Moreover, regular handwashing practice after sneezing was poor (37.1%). During the COVID-19 pandemic, 88.4% of participants increased the frequency of their handwashing during the pandemic compared to the pre-pandemic situation. About 82.52% of the participants used manual tap regularly for handwashing. Among all the participants, the mean frequencies of handwashing per day were 2.89 (± 0 .23 SD) times and 8.93(± 5.86 SD) times during pre-pandemic and pandemic situations respectively (Fig. 2a). This increased rate of handwashing practice during the COVID-19 is also coherent with other studies (Amegah, 2020; Roshan et al., 2020).

3.3. Overuse of water due to leaving the tap on while lathering and scrubbing the hands with soap

Among the 1980 participants, 1134 participants (57.27%) reported that they kept their tap on during lathering and scrubbing hands with soap (Fig. 2b). The average duration of lathering and scrubbing hands with soap per hand wash was 17.73 s among all the participants, and 17.95 s among the participants who kept their tap on (Table 1). To put Table 2 into perspective, an individual overused 1704.74 mL and 416.92 mL of water by a single handwash during the COVID-19 pandemic and pre-COVID-19 period respectively (Fig. 3). Besides that, an individual overused 14882.42 mL and 1163.20 mL of water per day during the COVID-19 pandemic and pre-COVID-19 period respectively. Therefore, by keeping the tap on during lathering and scrubbing hands with soap for handwashing, 1134 participants overused 12.79 times (16876 L vs 1319 L) more water per day during this pandemic compared to the pre-pandemic situation. Thus, 1134 participant's overused an extra 15,557 L of water during this pandemic for handwashing purposes which cost an extra 224.95 BDT or 2.64 USD per day (14.46 BDT/1000 L water) (BDnews24, 2020).

3.4. Limitation

The speed of the tap was set by the judgment of the experimenter. The number of participants for the experiment was not large enough and not country representative but from all divisions. Furthermore, we were unable to reach those participants who do not have an internet connection, and throughout the experiment and we were unable to observe the participants, so the study is not without some errors. We had no better solution during the countrywide lock-down situation.

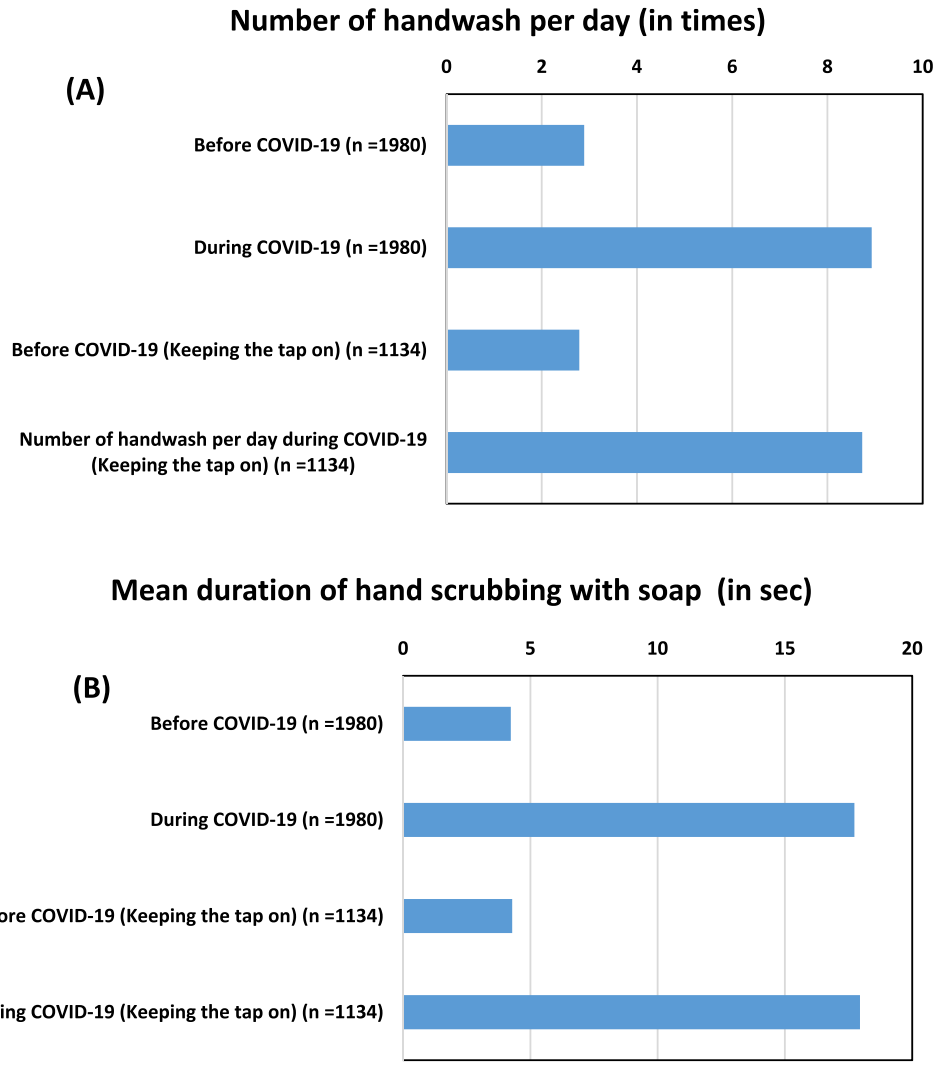

Fig. 2. Changes in the behavioral pattern of the participants before and during the COVID-19 with respect to a) mean number of daily handwashes per day (n = 1980) and number of handwashes with taps on (n = 1134); b) mean duration of hand scrubbing with soap (in sec) before and during COVID-19 (n = 1980) and with taps on (n = 1134).

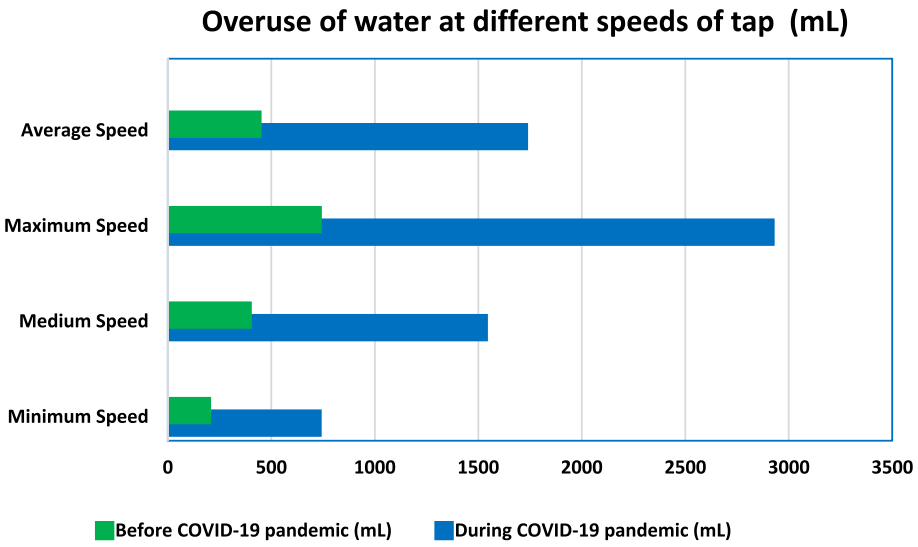

Fig. 3. Overuse of water during and before COVID-19 pandemic at different speeds of tap (n = 126).

However, it still gives a reasonable representation and we suggest a large-scale study with an economic evaluation regarding the overuse of water.

4. Conclusion and recommendation

While lathering hands with soap and scrubbing, a large number of people keep their tap on, thereby wasting 1179% of water during this pandemic compared to the pre-pandemic situation. This water and economic loss can be mitigated by good practice. One of the first things that we need to address is to minimize the speed of tap during handwashing. That would save 140% of water by them who keep their tap on during handwashing (57.27%) at least without relying on individual behaviors. It is also recommended to use push taps that automatically switch off after a period or sensor taps that are programmed to automatically turn on when hands are under the spout and immediately stop when the hands are taken away from the tap. Furthermore, behavioral change interventions are needed to make people aware in Bangladesh and similar low-income countries to shut off the tap at periods when water is not being used considering the limited water resources and respective potential stress on economics relevance to the overuse. However, from a policy point of view, it is important to know how much the overuse of water affect both the water supplies and the economic status to find an effective intervention. So further studies are required not only in Bangladesh but also worldwide. New findings of this study will benefit future research to comprehensively assess the economic impact associated with the overuse of water in developed and developing countries due to new hygiene rules and regulations imposed during the COVID-19 outbreak.

Definitions

Overuse of water: Overuse of water means the waste of water when people scrub their hands with soap, keeping the tap on.

Water flow: The water flow rate is the volume of water (mL) per unit time (s) that flows through the tap.

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Declaration of competing interest

The authors declare that they have no competing interests.

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References

Amegah, A.K., 2020. Improving handwashing habits and household air quality in Africa after COVID-19. Lancet Glob. Health 8 e1110–e1111.

BDnews24.com, 2020. Dhaka WASA raises water price by 24.97% for households. Available at: https://bdnews24.com/bangladesh/2020/02/28/dhaka-wasa-raises-water-price-by-24.97-for-households.

Boyce, J.M., Pittet, D., 2002. Guideline for hand hygiene in health-care settings: recommendations of the healthcare infection control practices advisory committee and the HICPAC/SHEA/APIC/IDSA hand hygiene task force. Infect. Contr. Hosp. Epidemiol. 23.

Burton, M., Cobb, E., Donachie, P., Judah, G., Curtis, V., Schmidt, W.-P., 2011. The effect of handwashing with water or soap on bacterial contamination of hands. Int. J. Environ. Res. Publ. Health 8, 97–104.

CDC, 2020. Prevent getting sick. Available at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html.

Conversation, 2020. Coronavirus: what might more hand washing mean in countries with water shortages? Available at: https://theconversation.com/coronavirus-what-might-morehand-washing-mean-in-countries-with-water-shortages-134625.

Eysenbach, G., 2004. Improving the quality of web surveys: the checklist for reporting results of internet E-surveys (CHERRIES). J. Med. Internet Res. 6, e34.

Haque, T., Hossain, K.M., Bhuiyan, M.M.R., Ananna, S.A., Chowdhury, S.H., Ahmed, A., Rahman, M.M., 2020. Knowledge, Attitude and Practices (KAP) towards COVID-19 and Assessment of Risks of Infection by SARS-CoV-2 Among the Bangladeshi Population: an Online Cross Sectional Survey.

Hedrick, S., 2018. Water in crisis-spotlight on Bangladesh. Water Project 213–214.

Hoque, M.A., Hoque, M.M., Ahmed, K.M., 2007. Declining groundwater level and aquifer dewatering in Dhaka metropolitan area, Bangladesh: causes and quantification. Hydrogeol. J. 15, 1523–1534.

Khan, M.R., Koneshloo, M., Knappett, P.S.K., Ahmed, K.M., Bostick, B.C., Mailloux, B.J., Mozumder, R.H., Zahid, A., Harvey, C.F., Van Geen, A., 2016. Megacity pumping and preferential flow threaten groundwater quality. Nat. Commun. 7, 1–8.

Kirchherr, J., Charles, K., 2018. Enhancing the sample diversity of snowball samples: recommendations from a research project on anti-dam movements in Southeast Asia. PloS One 13, e0201710.

Kundu, S., Sayeed, A., Al Banna, M.H., Begum, M.R., Kormoker, T., Brazendale, K., Hasan, M.T., Habiba, S.J., Abid, M.T., Khan, M.A., 2020. Knowledge, Attitudes, and Practices towards Measures for Prevention of the Spread of COVID-19: an Online Cross-Sectional Survey Among Bangladeshi Residents. PsyArXiv. Available at: https://doi.org/10.31234/osf.io/cxp8n.

Lu, T., Smout, I.K., 2008. Domestic water consumption: a field study in Harbin, China. In: Conference contribution. Loughborough University. Available at: https://hdl.handle.net/2134/28765.

Mojid, M.A., Parvez, M.F., Mainuddin, M., Hodgson, G., 2019. Water table trend—a sustainability status of groundwater development in North-West Bangladesh. Water 11, 1182.

Park, J.-H., Cheong, H.-K., Son, D.-Y., Kim, S.-U., Ha, C.-M., 2010. Perceptions and behaviors related to hand hygiene for the prevention of H1N1 influenza transmission among Korean university students during the peak pandemic period. BMC Infect. Dis. 10, 222.

Rohilla, S.K., 2020. COVID-19 outbreak: more hand washing can increase India's water woes. Available at: https://www.downtoearth.org.in/blog/water/covid-19-outbreak-more-hand-washing-canincrease-india-s-water-woes-69900.

Roshan, R., Feroz, A.S., Rafique, Z., Virani, N., 2020. Rigorous hand hygiene practices among health care workers reduce hospital-associated infections during the COVID-19 pandemic. J. Primary Care Commun. Health 11, 2150132720943331.

Sayeed, A., Kundu, S., Banna, M.H. Al, Hassan, M.N., 2020. COVID-19 outbreak: water loss during handwashing, need more concern? Popul. Med. 2, 1–2.

Tao, S.Y., Cheng, Y.L., Lu, Y., Hu, Y.H., Chen, D.F., 2013. Handwashing behaviour among Chinese adults: a cross-sectional study in five provinces. Publ. Health 127, 620–628.

Un, D., 2014. 2014 revision of the World Urbanization Prospects. United Nations Department of Economics and Social Affairs, Population Division, New York, NY, USA. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjd9dqMyuTuAhVYaCsKHZfUC8YQFjAAegQIAhAC&url=https%3A%2F%2Fwww.un.org%2Fen%2Fdevelopment%2Fdesa%2Fpublications%2F2014-revision-world-urbanization-prospects.html&usg=AOvVaw1jabw_VgTO-z1PJozYU9bm.

UNICEF, 2020. Everything you need to know about washing your hands to protect against coronavirus (COVID-19). Available at: https://www.unicef.org/bangladesh/en/everything-you-need-know-about-washing-your-hands-protect-against-coronavirus-covid-19.

Venture, G., 2007. How to Conduct a Flow Rate Test. Available at: http://www.greenventure.ca/ecohouse/tours/wisewateruse/003/printer.html.

van der Voorn, T., van den Berg, C., Bhattacharya, P., Quist, J., 2020. Never waste a crisis: drawing first lessons from the COVID-19 pandemic to tackle the water crisis. ACS ES&T Water.

Wadood, M.A., Mamun, A., Rafi, M.A., Islam, M.K., Mohd, S., Lee, L.L., Hossain, M.G., 2020. Knowledge, Attitude, Practice and Perception Regarding COVID-19 Among Students in Bangladesh: Survey in. Rajshahi University, MedRxiv.

Who, 2020. Guideline of handwash during COVID-19. Available at: https://apps.who.int/iris/bitstream/handle/10665/331846/WHO-2019-nCoV-IPC_WASH-2020.3-eng.pdf?ua=1.

Who, 2020. Water, sanitation, hygiene, and waste management for the COVID-19 virus. Available at: https://apps.who.int/iris/bitstream/handle/10665/331846/WHO-2019-nCoV-IPC_WASH-2020.3-eng.pdf?ua=1, 2020.

Widmer, A.F., 2000. Replace hand washing with use of a waterless alcohol hand rub? Clin. Infect. Dis. 31, 136–143.

Williams, J.R., 2008. The Declaration of Helsinki and public health. Bull. World Health Organ. 86, 650–652.