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Evaluating knowledge, awareness and associated water usage towards hand hygiene practices influenced by the current COVID-19 pandemic in Bangladesh

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HIGHLIGHTS

• The outbreak of COVID-19 has greatly influenced individual’s hand hygiene practice
• Increased water demand has been created due to the changes in hygiene practice
• Adequate hygiene education is important for maintaining effective hand hygiene
• Social awareness is crucial for sustainable water management and healthy life
• Water pricing and academic curriculum improvement are recommended

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ABSTRACT

Hand hygiene is considered as one of the most effective ways for preventing transmissible diseases, especially for preventing virus-borne diseases. The study has been conducted to evaluate changes in knowledge, awareness and practices of hand hygiene due to the outbreak of the coronavirus disease (COVID-19) in Bangladesh. The potential factors influencing human behaviours for maintaining hand hygiene have also been explored. Moreover, a probable increase in daily water demand associated with the changed situation has been assessed. An online survey was performed among a total of 367 Bangladeshi residents about their practices of hand hygiene during pre-corona, corona, and of their perceived future practices at post-corona period. It has been observed that a significant percentage (62.1%) of the respondents have received basic hygiene education at any level of their academic education. Nevertheless, their hygiene practices were very poor before the COVID-19 pandemic. The outbreak of the COVID-19 has reinforced their previous knowledge and greatly influenced their behavioural changes towards practicing hand hygiene as per World Health Organization guidelines for preventing the virus outbreak. The changes, however, have created increased water demand. The estimated water usage is found to be 2.68 times (9.15 L/c/d) and 2.52 times (8.59 L/c/d) higher in the corona and post-corona period respectively than that of the pre-corona situation (3.41 L/c/d). The principal component analysis (PCA) elucidated that an
1. Introduction

Safe water, sanitation and hygiene (WASH) provisions play a critical role to protect public health against infectious diseases caused by various pathogenic microorganisms. In this regard, hand hygiene is considered as one of the most effective barriers against a number of pathogenic diseases as maintaining proper hand hygiene substantially reduces the rate of incidence of different communicable diseases including diarrhoea (Najnin et al., 2017; Wichaidit et al., 2019; Ejemot-Nwadiaro et al., 2020), cholera (Dunke et al., 2011; Gidado et al., 2018; Richter et al., 2018; Wichaidit et al., 2019), influenza (Park et al., 2010; Simmerman et al., 2011; Liu et al., 2016) and pneumonia (Arabi et al., 2008; Koff et al., 2011). On the other hand, poor handwashing may significantly contribute to increased risk of foodborne illness (Shapiro et al., 2011; Ali et al., 2014; Vaccaro, 2018; Anderson, 2020). The majority of people, particularly in developing countries, lack adequate knowledge of effective hand hygiene and are reluctant as well to maintain proper handwashing practices. In this context, the severity of current pandemic due to the deadly contagious coronavirus disease (COVID-19) strengthens earlier pronouncements on appropriate and effective WASH measures for ensuring safety of public health, recommending as well a closer and stronger coordination between these two sectors (Donde et al., 2021). Since handwashing with soap is one of the efficacious means to remove pathogens and to prevent the spread of infectious diseases, the necessity of maintaining personal hygiene, especially hand hygiene with soap or alcohol-based sanitizer, has been highly emphasized to put a stop to the spread of COVID-19 (Zivich et al., 2018; Suen et al., 2019; Hadaway, 2020; Leslie et al., 2021). However, the first experience of COVID-19 has taught that different types of nature-based, localized and radical solutions are required instead of only the laissez-faire solution (van der Voorn et al., 2021).

Since the first identification of COVID-19 in Wuhan, China in December 2019, more than 206.95 million cases have been registered worldwide, leading to more than 4.36 million deaths (WHO, 2021). The World Health Organization (WHO) has declared it as a pandemic and global threat to public health. This virus transmits primarily through the respiratory droplets from an infected person by coughing and sneezing (Pendar and Páscoa, 2020). Maintaining social distances, wearing of face mask in public places and the usage of personal protective equipment by frontline health care provisioners etc. are highly recommended in containing the pandemic until an effective treatment policy and universal vaccination against COVID-19 are available (WHO, 2020; Xu et al., 2020; Zowalaty and Järhult, 2020; Donde et al., 2021). However, there is a high possibility of infection through touching of contaminated surfaces and subsequent touching of eyes, noses or mouths before washing or sanitizing hands. Zhou et al. (2021) found extensive viral RNA contamination of surfaces and air over a range of critical healthcare environments in London in the absence of cultured virus, and therefore, emphasized on the effective usage of personal protective equipment, social distancing, and hand/surface cleanliness. Another study by Chia et al. (2020) observed high touch surface contamination in 10 (66.7%) out of 15 patients in the first week of illness, and in 3 (20%) after the first week of sickness in hospital rooms of China. International organizations like WHO, UNICEF have, therefore, repeatedly emphasized on performing handwashing thoroughly with soap and water or sanitizing hands with alcohol-based hand rub to form a barrier against transmission of coronavirus. Like many other countries, the level of concern regarding virus transmission has increased the probability of washing hands with soap under flowing water for a minimum of 20 s (s) at least five times a day in Sub-Saharan Africa (Amukwaa-Mensah et al., 2021). Based on a comprehensive dataset of 176 countries, Dzator et al. (2020) reported that handwashing facility lessened total and new confirmed cases of COVID-19. Nevertheless, maintaining proper practices of handwashing during the pandemic period is challenging particularly in developing countries. This might be ascribed to the peoples’ socio-economic status, lack of their self-consciousness, access to reliable water supply etc. Practicing frequent handwashing also leads to an increased demand of water. In a study, Zvobgo and Do (2020) reported that an extra 4.5 L/c/d of water was needed to practice safe handwashing as recommended by WHO which ultimately increased domestic water demand by 9% in Chitungwiza, Zimbabwe. The scenarios are more or less similar for countries where supplied water often fails to fulfil peoples’ basic demand. However, the quality of water to be used for washing hands is very crucial to prevent the transmissible diseases. Enhancing microbiological quality of water is, therefore, essential to promote hand hygiene (Howard et al., 2020; Berhanu et al., 2021) and to reduce health risk.

Bangladesh is also facing the challenges of the pandemic since the confirmation of first infection of COVID-19 on March 8, 2020, followed by rapid increase in confirmed new infections and deaths as well (IHDCR, 2020). Although the first infection in the country was recorded after about 4 months from the emergence of COVID-19 infection in China, the country had to suspend immediately many normal activities, and take few measures such as lockdown, self-quarantine, self-isolation etc. to contain the virus infection. However, this sudden lockdown and imposed quarantine have caused major psychological impact across Bangladesh (Mamun, 2021) which might be ascribed to the country’s over-stretched healthcare facilities and socio-economic status. Due to the lack of specific treatment options for COVID-19 and unavailability of vaccination program for all, significant emphasis has been given on the maintenance of proper hand hygiene considering it as an effective preventive strategy for controlling the infection in both hospitals and community settings in the country. However, there might be discrepancies between the knowledge of key hygiene messages to control any communicable disease and the practices of proper hygiene behavior especially in developing countries like Bangladesh. Rabbi and Dey (2013) conducted a study in 50 sub-districts of Bangladesh on adult female members who had knowledge of day-to-day associated activities of water, sanitation and hygiene during 2006–2011. Although 95% of the respondents reported the necessity of handwashing before taking food, only 8% of them used to do that in 2006, which however, was increased to 22% in 2011. The changes were ascribed to the various interventions offered to the people of the areas by the WASH program of BRAC (Bangladesh Rural Advancement Committee). Islam et al. (2021) has reported in a study in Bangladesh that WASH is mainly influenced by gender, profession, place of residence, and level of education of the attendees. In another study, it has been found that the overall prevalence of household handwashing was 56.3% which significantly varied across the socio-economic status of the households (Ahmed and Yunus, 2020). However, frequency of handwashing has been found to be substantially higher during the pandemic situation than the pre-pandemic period, and associated water demand has also been increased during this COVID-19 pandemic in different parts of the world (Amegah, 2020; Głąbska et al., 2020; Pung et al., 2020; Rohilla, 2020; Roshan et al., 2020).
Amukwa-Mensah et al. (2021) reported that the increase in the likelihood of handwashing due to the concern of COVID-19 are 3% for Benin and 6.3% for South Africa. However, people are generally unaware about wastage of water made by keeping the tap on throughout the whole handwashing process such as keeping the tap on unnecessarily during the times of lathering and scrubbing hand with soap (Sayeed et al., 2020). In a web-based survey conducted in the context of Bangladesh, Sayeed et al. (2021) reported that the overuse of water for keeping the tap on while lathering or hand scrubbing with soap was increased by 13-fold in this pandemic compared to that during the non-pandemic situation. It was observed in their study that approximately 14.9 L of water per person per day was overused keeping tap on throughout the handwashing process. The country is amongst the low water stress countries having baseline water stress of 0.65 for all sectors (WRI, 2013), and 97% of the total population have access to water (WHO, 2019). However, the excess demand and/or overuse of water may affect significantly the water availability of the country. On the other hand, the surface water sources of the country are being polluted by unlimited disposal of toxic and hazardous waste, and groundwater in many regions of the country bears toxic and potentially toxic metals. Therefore, the combined effect of this excess water demand and polluted water source may become critical in future for sustainable water management of the country.

Human behaviour, especially health related behaviour, is the consequence of multiple impacts from their biology, culture, education and environment, and therefore, modifications of this behaviour is a complex task (WHO, 2009). The WHO, therefore, called for various theory-based researches to figure out the determinants of the hand hygiene behaviour which would help design more effective interventions. Numerous behavioural frameworks such as IBM-WASH (the Integrated Behaviour Model for WASH), the RANAS (The Risks, Attitudes, Norms, Abilities and Self-regulation) model, the FOAM (Focus on Opportunity, Ability, and Motivation) model, Theory of Planned Behaviour etc. have been used for identifying and classifying the determinants of behaviour in different ways in WASH practices. The identified determinants of handwashing by these theories are mainly knowledge, risk, attitude, social norm, ability, opportunity, infrastructure, motivation, and personal characteristics such as gender, education, income etc. (White et al., 2020). In the current situation of the COVID-19 pandemic, it is obvious that maintaining a proper personal hygiene, particularly the hand hygiene, is essential for a healthy living. However, the human behaviour and reactions to stick with guidelines of health hygiene in the new normal situation need to be explored for adoption of effective services in this regard. In this backdrop, this study aims at assessing the knowledge, awareness and practices towards maintaining proper hand hygiene in order to prevent infectious diseases such as COVID-19 in Bangladesh. Associated factors that govern human behaviours to pay attention on hand hygiene have also been explored. As the availability of potable water is limited, the excess water demand to maintain hand hygiene during the current pandemic has also been evaluated which might help set action plans to maintain a healthy environment towards sustainable water resource management in the country.

2. Methods

2.1. Study participants and procedure

The study is based on an online survey conducted from May 21 to June 21, 2020, during the first wave of COVID-19 in the country, using a structured questionnaire in Google survey tool (Google Form). The survey was done involving people of different ages, educational backgrounds, genders and social status. Many researchers have adopted this type of online survey procedure during the pandemic situation (Głębska et al., 2020; Islam et al., 2020; Sayeed et al., 2021). Information about the questionnaire was disseminated through social networks, e-mail and personal communication, and the participants were requested to voluntarily take part in the survey. Most of the participants were residents of Bangladesh although a group of Bangladeshi people residing in UK, USA, Canada, Australia and Germany also participated in the survey. However, further analysis on the responses from outside of the country have been excluded in this study to focus specifically on the situation of Bangladesh. A total of 367 participants from Bangladesh finished the whole survey, bringing about a response rate of 95.4%. The first part of the questionnaire is dealt with questions relating to socio-economic status of the participants while in the second part, the participants’ knowledge of COVID-19 was assessed. In the last section, the participants responded to questions regarding their hand hygiene knowledge and practices for preventing various water-related diseases including the COVID-19. Few questions had multiple responses, and a few questions were kept optional to answer. The study was designed for data collection considering three periods such as pre-corona, corona and post-corona periods. The pre-corona period means the time before the outbreak of COVID-19, and the corona period is the situation during the current pandemic period. The post-corona period is assumed to be the period of expected normalcy at the end of the current pandemic. The post-corona period has been taken into consideration to perceive about peoples’ hand hygiene practices and its sustainability after the pandemic. The key issues of the questionnaire addressed in this study have been presented in Table 1.

2.2. Estimation of water consumption for individual’s handwashing

The estimation of water consumption for handwashing was based on the responses received in the study and on few assumptions adopted from Zvobgo and Do (2020), Staddon et al. (2020) and Sayeed et al. (2021). Zvobgo and Do (2020) noted that a person practiced safe handwashing on an average three times a day, each time for a duration of 40–60s with estimated average amount of 1.5 L water. On the other hand, Staddon et al. (2020) found an average consumption of 2–3 L per capita of running water from the wash basin for every handwash routine performed following proper guidelines of COVID-19 regulations. It is reported later in this paper that most of the respondents washed their hands for less than 20s before the current pandemic and for 20–30s during the corona period. It is expected that the usage of water in future may be same or more with longer periods of handwashing routine to maintain safe hygiene. However, total water consumption per person per handwash has been evaluated in the study considering the average duration (15s for pre-corona and 25s for corona and post-corona) of washing hands keeping the water source on and with the minimum water usage of 2 L per wash. Average frequencies of handwash were assumed as 3, 8, 15, 18, 9 times a day which were reasonably based on

Table 1

| Part-1: Socio-economic information |
|----------------------------------|
| 1. Gender, age, education, area of living |
| 2. Occupation and monthly income |
| 3. Hygiene education and its importance to prevent communicable disease and COVID-19 |

| Part-2: Knowledge on COVID-19 |
|-------------------------------|
| 1. Awareness of coronavirus and COVID-19 outbreak (yes/no) |
| 2. Source of information about COVID-19 (multi-response) |
| 3. Knowledge of effective preventive measures against COVID-19 (multi-response) |

| Part-3: Hand hygiene practices (for pre-corona, corona and post-corona periods) |
|-------------------------------|
| 1. Types of disinfectants used by individuals |
| 2. Sources of water for handwashing |
| 3. Duration and frequency of handwashing |
| 4. Mode of hand drier used by individuals |
| 5. Necessity of inclusion of hygiene education in any level of education (yes/no) |
| 6. Adequacy of respondent’s received education to date for fighting against coronavirus (yes/no) |
variable options considered in the study such as <5 times, 5–10 times, >10 times, every hour and only when required, respectively.

2.3. Data management and statistical analysis

The data were extracted in Microsoft Excel 2019 from the responses received in google form, and necessary editing, screening and coding were done in Excel. The excel file was then imported into SPSS software (IBM SPSS 22.0) for statistical analysis. Descriptive statistics such as first-order analyses (chi-square tests, degree of freedom, p-value, etc.), both the linear (univariate and multivariate) and logistic regression were performed with a 95% confidence interval to find out remarkable associations between the pattern of handwashing and different socio-economic characteristics of the respondents.

Principal component analysis (PCA) has also been conducted in the study to evaluate the weightage association among the socio-economic variables, and to recognize the important factors governing the pattern of handwashing of respondents by using SPSS (version 22.0) software. The Kaiser-Maier-Olkin (KMO) and Bartlett’s sphericity tests were also performed to ensure the suitability of this data set for PCA. The recommended KMO and Bartlett’s sphericity test values for any data set suitable for PCA are greater than 0.5 and less than 0.05, respectively (Rojas-Valverde et al., 2020; IBM, 2021). The obtained value of KMO was 0.667 while that of Bartlett’s sphericity test was less than 0.01 implying that the studied datasets were suitable for PCA (IBM, 2021). PCA is the transformation of the original variables of a data set into a set of new and uncorrelated variables which are known as the principal components (PCs), and the process is widely used to lessen data and to extract a small number of dormant factors for analysing associations among the observed variables (Bodru-Doza et al., 2020; Hossen et al., 2021). A component having eigenvalues of smaller than one is considered as less significant, and therefore, such an observed variable could be disregarded (Rahman et al., 2020). Correlation matrix and varimax rotation with Kaiser Normalization have been used in the study, and the components with eigenvalues greater than one have been taken for further analysis. The loadings, one of the outcomes of PCA, are the values that represent the contribution of each variable to any particular principal component. Large loadings (positive or negative) stipulate that a particular variable has a strong association to a particular principal component. In this study, the estimated loadings in PCA have been categorized as ‘strong’, ‘moderate,’ and ‘weak’ for values of >0.75, 0.75–0.50, and 0.50–0.30, respectively, according to Liu et al. (2003) and Rahman et al. (2020). The categorization has been used to figure out dominant socio-economic variables along with their weightage values for peoples’ handwashing behaviour during the three different situations considered in the study.

3. Results and discussions

3.1. Socio-demographic details of the respondents

The level of awareness regarding the transmission of COVID-19 and its various preventive measure depends significantly on various socio-economic, behavioral and psychological factors notably as gender, age, level of income, availability of handwash facilities, outdoor activities, mental trauma etc. (Jin et al., 2020; Liu et al., 2020; Amuakwa-Mensah et al., 2021). Amuakwa-Mensah et al. (2021) observed a heterogeneous effect of level of concern about the spread of COVID-19 on frequency of handwashing over gender, age group and water sources in 12 sub-Saharan African countries. Therefore, respondents of varying genders, ages, occupations and economic conditions have been accommodated in this study to figure out their possible impact of handwashing practices. The socio-demographic details of the participants have been summarized in Table 2. Among a total of 367 participants, the percentage of male and female participants are 75.5% and 24.5%, respectively. Although the survey was grouped among people of different age groups up to 50 years, most of the respondents were found to be within the age group of 25–50 and 18–24 years group accounting 48.5% and 47.7% of the total respondents respectively. Most of the participants were students (52.0%), and the rest are from different occupational fields. Regarding the income level considered in the study, monthly income of the majority (over 50%) of the total respondents was below 10,000 BDT (120 US$) while around 19% respondents reported their income within 25000–50000 BDT (300–600 US$). It is assumed that the level of education might significantly affect the practice of handwashing among student respondents since hygiene education is conducted to some extents at various levels of academic curriculum in the country. Therefore, the level of education of the participants was also requested to be answered in the questionnaire. The respondents’ highest level of education was identified as graduate (45.0%) followed by Higher Secondary Certificate (HSC) (25.9%), postgraduate (24.8%), others (3.5%) and Secondary School Certificate (SSC) or below (0.8%). The lowest percentage of the last group might be ascribed to the fact that they had lack of knowledge or facilities in this regard or were not well versed with online survey. As shown in Fig. 1, respondents were randomly chosen from eight divisional cities of Bangladesh and most of the respondents were residents of Dhaka and Chattogram, the two biggest cities of Bangladesh.

| Table 2 |
|-----------------------------|-----------------------------|-----------------------------|
| Variables                  | Frequency (n = 367)          | Percentage (%)               |
| Gender                     |                             |                             |
| Male                       | 277                         | 75.5                        |
| Female                     | 90                          | 24.5                        |
| Age                        |                             |                             |
| < 18 years                 | 4                           | 1.1                         |
| 18–24 years                | 175                         | 47.7                        |
| 25–50 years                | 178                         | 48.5                        |
| Others                     | 10                          | 2.7                         |
| Highest Education Level    |                             |                             |
| SSC or below               | 3                           | 0.8                         |
| HSC                        | 95                          | 25.9                        |
| Graduate                   | 165                         | 45.0                        |
| Postgraduate               | 91                          | 24.8                        |
| Others                     | 13                          | 3.5                         |
| Monthly income (in BDT)    |                             |                             |
| < 10000                    | 185                         | 50.4                        |
| 10000 - 25000              | 20                          | 5.5                         |
| 25001 - 50000              | 70                          | 19.1                        |
| 50001 - 75000              | 35                          | 9.5                         |
| 75001 - 100000             | 23                          | 6.3                         |
| >100000                    | 34                          | 9.2                         |
| Occupation                 |                             |                             |
| Student                    | 191                         | 52.0                        |
| Academician                | 44                          | 12.0                        |
| Pvt. Employee              | 74                          | 20.2                        |
| Govt. Employee             | 39                          | 10.6                        |
| Businessman                | 4                           | 1.1                         |
| Medical Person             | 2                           | 0.5                         |
| Unemployed                 | 13                          | 3.6                         |
| Area                       |                             |                             |
| Bangladesh                 | 332                         | 90.5                        |
| Others                     | 35                          | 9.5                         |

3.2. Personal knowledge and awareness regarding preventive measures against COVID-19

The study found that around 97.7% of the respondents heard about coronavirus, and 78.2% of them knew its preventive measures which were close to the findings reported by Islam et al. (2021). Islam et al. (2021) found that 89.8% of the respondents knew about the COVID-19 and its various preventive measures. The different sources of information dissemination regarding COVID-19 were also analyzed in the study, and the percentage of different sources of information about COVID-19 has been summarized in Fig. 2. As shown in Fig. 2, the responses are...
diverse covering different media for information dissemination. As expected, the social media stands first in choice and has played the most important role delivering the message of COVID-19 outbreak. The newspaper, television, government authorized websites also have contributed significantly to spread the news of COVID-19 outbreak to the respondents. Social networking is an appropriate way for individuals and societies to remain linked, and to make better judgements in any circumstances. It has played a very critical role during the current pandemic while people were largely isolated from each other. The fewer responses about information from work places and NGOs were as expected since the activities of those workplaces remained postponed during the COVID-19 shutdown.

Besides wearing various protective masks and personal protective equipment, different preventive measures taken by respondents against coronavirus have been presented in Fig. 3. Most of the respondents highlighted a number of different preventive measures against COVID-19 such as washing hands frequently using liquid handwash or sanitizer, maintaining social distance, staying at home, avoiding close contact with people who were unwell, and avoiding touching of eyes, nose and mouth without washing hands. While these responses are likely to be biased by the health regulations declared by the health organizations, the range of preventive measures reported as the best adopted options might also be reflective of the diverse socio-economic conditions of the sampling population. Maintaining social distance as one of the preventive measures ranks the top in the responses although it is very difficult to maintain such a practice in countries like Bangladesh, where population density is among the highest in the world. Avoiding to touch eyes, mouth, nose without handwashing and frequent handwashing with soap or alcohol-based sanitizers are ranked 2nd and 3rd in this survey. These responses are perhaps reflective of the success of information
dissemination about the most effective ways of protective measures as suggested by WHO and relevant health authorities of the country. However, only about 12% (the lowest percentage) of the respondents believed vaccination only as a preventive measure against COVID-19 which might be due to the fact that vaccination was not readily available in Bangladesh during the time of the survey.

3.3. Handwashing practice and its changes due to the pandemic situation

3.3.1. Handwashing duration and frequency

WHO recommends washing hands with soaps or sanitizing hands using any alcohol-based sanitizer for at least 20–30s to avoid infection from virus-borne diseases, especially from the COVID-19. It is found in the study that most of the people have already had the basic knowledge to maintain general hand hygiene to be safe from any transmissible disease, such as diarrhea, cholera etc. The level of hand hygiene practices, however, was found to be very poor before the pandemic situation. It has been found that most of the people (75.3%) washed their hands for less than 20s during the pre-corona period. However, the practice has been drastically changed due to this pandemic situation. The percentage of people washing hands for 20–30s has been found as 77.5% during the COVID-19 pandemic while 64.94% of the respondents reported that they would continue the practice when the pandemic becomes over as well. It is identified that many of the respondents who washed their hands only when required or less than five times a day before the pandemic, have started to wash their hands 5 to 10 times daily during the pandemic period. The pattern of handwashing duration and frequencies as reported in the study have been shown in Fig. 4 and Fig. 5. It is found from the survey that around 40% people washed their hands less than five times daily before the pandemic situation and this percentage has been reduced to 7% during the corona period. Almost 46% (170) of the respondents washed their hands 5 to 10 times a day during corona period whereas only 4% of the respondents did that only when it was required.

As suggested by the UNICEF, there is some specific time to wash hands in general while for coronavirus prevention, it is recommended to wash hands with soap or disinfect with any other alcohol-based hand sanitizer whenever required. Although the higher percentage of people reported to wash their hands 5–10 times a day during corona period, the respondents might not specifically consider the recommendations of UNICEF or WHO. The respondents also ensured that they would continue to maintain their hand hygiene even after the pandemic situation. It is encouraging to notice that 47% of people mentioned to wash their hands 5–10 times a day in the post-corona period. This might be reflective of the fact that the severity of COVID-19 has made people more conscious about the importance of hand hygiene as well as their personal hygiene.

A comparison of overall scenario of handwashing frequency during pre-corona, corona and perceived future practice at post-corona period has been presented in Table 3. The comparison has been made based on the responses received in the study which reflects the significant changes in public awareness about hand hygiene due to the severity of COVID-19 outbreak. It is obvious that the COVID-19 pandemic situation has made the behavioural change among people, and they have now realized the necessity of more frequent handwash even when the pandemic situation becomes over. Amongst the 145 (39.5%) respondents who used to wash their hands less than 5 times a day before pandemic situation, have started to wash their hands more frequently. Among that 39.5% respondents, 67.6% have changed their practice to 5–10 times a day during corona period, and 60.6% of them reported they would continue the practice in the post-corona period.

Changes in handwashing frequencies with respect to the participants’ educational level during the three considered situations has been depicted in Fig. 6. It shows that most of the respondents with educational level of SSC or below used to wash their hands less than 5 times a
3.3.2. Type of disinfectants and mode of hand dryer

The use of proper type of disinfectants, and drying hands completely with clean cloth or paper towel are very important in order to remove all traces of various microorganisms from hands. Fig. 7 shows the usage of various disinfectants by the participants during the three periods considered in the study. It has been found that most of the people washed their hands with only water, or with plain soap or antiseptic liquid handwash during pre-corona period. However, the use of hand sanitizer (with or without alcohol) was found to be remarkably high (53%) during the corona period followed by antiseptic liquid handwash, detergents or soapy water and only alcohol-based handwash or hand sanitizer. The number of people using plain soap has been decreased from 50% to 30% while the usage of hand sanitizer (with or without alcohol based) is increased by 29.5% after the COVID-19 outbreak. Although washing hands with only water was significantly decreased, few (9.5%) people still used only water during corona period which perhaps due to the unavailability or lack of capacity of buying soaps. However, the significant changes in the use of various disinfectants by the participants implies that the COVID-19 outbreak has made the people more aware about maintaining their hand hygiene.

Handwashing practice with soap generally increases during epidemics due to the fear of being sick and due to increased awareness of the practice to prevent transmission (UNICEF and WHO, 2021). In China, the outbreak of COVID-19 has caused tremendous rise in the household consumption of disinfectants, and alcohol-based disinfectants are considered as the most preferred products for hand sanitization (Guo et al., 2021). The increase in using hand sanitizer in this study shows consistency with the findings reported by Choi et al. (2021) who found the increased rate of hand sanitizer uses during the pandemic.

Fig. 6. Comparison of participant’s handwashing frequencies to their educational level.

Fig. 7. Type of disinfectants for washing hand.

Table 3

| Frequency of handwash | Pre-corona, n (%) | Percentages of responses from respondents with respect to pre-corona Corona (%) | Post-Corona (%) |
|-----------------------|------------------|-----------------------------------------------------------------------------|------------------|
|                       | <5 times         | 5-10 times                     | >10 times        | Only when required | Every hour        | <5 times | 5-10 times | >10 times | Only when required | Every hour |
| Pre-corona            |                 |                                |                  |                   |                   | <5 times | 5-10 times | >10 times | Only when required | Every hour |
|                      | 145 (39.5)       | 126 (34.3)                     | 28 (7.6)         | 64 (17.4)         | 4 (1.1)           |          |            |           |                   |            |
|                      | 13.1             | 67.6                           | 13.1             | 5.5               | 5.5               | 47.2       | 50.8        | 0.0        | 0.0               | 0.0         |
|                      | 5-10 times       |                                |                  |                   |                   | 20.7       | 66.7        | 10.6       | 1.4               | 6.9         |
|                      | 0.8              | 42.1                           | 50.8             | 6.3               | 0.8               | 36.5       | 53.2        | 36.5       | 2.4               | 7.1         |
|                      | 0.0              | 64.3                           | 0.0              | 35.7              | 0.0               | 75.0       | 70.0        | 10.7       | 14.3              |            |
|                      | 7.8              | 29.7                           | 18.8             | 18.8              | 6.3               | 25.0       | 14.1        | 42.2       | 12.5              |            |
|                      | 0.0              | 25.0                           | 0.0              | 75.0              | 0.0               | 0.0        | 0.0         | 100.0      |                   |            |
| Total, n (%)         | 367 (100)        |                                |                  |                   |                   | 25 (6.8)   | 170         | 114        | 41 (11.2)         | 171         |
|                      | (46.3)           |                                | (31.1)           | (9.5)             | (46.6)            | (28.8)     | (46.6)      | (9.5)      | (28.8)            | (46.6)      |
observed that consumer perception of the products’ preventative effects against COVID-19 was higher for liquid hand soap and hand sanitizer than that was for normal bar soap. Hand sanitizer use was also liked by household members in rural Bangladesh during the coronavirus pandemic (Yeasmin et al., 2021). Yeasmin et al. (2021) reported that participants of their study thought soap and water eliminated dirt from their hands while hand sanitizer killed germs. However, a sufficient volume of alcohol-based hand rub is recommended for sanitizing hands when water and soap are not available.

It is noted from the study that general awareness about the hand hygiene has been significantly raised among people, and they consider it important to continue the hygiene practices even after the pandemic. However, many of the respondents are still ignorant about the efficacy of a particular type of disinfectant against the corona virus. This is reflected in the findings of the study among the respondents who are still unaware about the effectiveness of using only soap or alcohol-based sanitizer to prevent contamination by corona virus. Therefore, people should be educated about selecting disinfectants for specific uses as well as to avoid any adverse dermatological effects which may arise from their improper use.

Araghi et al. (2020) reported that handwashing practice is influenced by the availability of soap or other disinfecting agent without taking family income into consideration. Another study carried out by Wichaidit et al. (2019) noted that people who lived in poverty generally avoided using soap or other disinfecting agents for handwashing mainly due to the lack of purchasing capacity of necessary products. In this connection, the variation in uses of different types of disinfectants with the participants’ income level has been evaluated in the study, and respective changes for the three considered periods are shown in Fig. 8. During the pre-corona period, most of the respondents (39%) having monthly income less than 10000 BDT (Income group I) used either plain soap or antiseptic soap or handwash or sanitizer. On the other hand, majority of the participants having monthly income of 10000–25000 BDT (Income group II) and of 25000–50000 BDT (Income group III) were habituated to use all types of disinfectants available in the local market. It has been observed that a relatively higher percentage (47%) of people of income group I used all types of disinfectants without considering their effectiveness against coronavirus as mentioned earlier. However, sanitizing agents for preventing corona virus has been chosen by a relatively higher percentage of participants (62.5%) of income group II. No strong correlation is observed between income level and choice of disinfectant types. The findings of the study reveal that selection of disinfectant types has been influenced by the households’ monthly income, and the highest changes has been observed in the people of group II. It has been generally observed that the current pandemic has strong influence on the use of disinfecting agents irrespective of its types and nature, or irrespective of participants’ level of income. As the number of respondents of monthly income greater than 500000 BDT is insignificant, a specific conclusion cannot be drawn in this regard.

Drying hands after washing is a critical step for maintaining effective hand hygiene. Although microbes can transfer more easily to and from wet hand (CDC, 2020; Marcenac et al., 2021), the message of drying hands has not been pronounced yet that much. It has been found in the study that most of the respondents practiced hand drying applying different modes. Fig. 9 shows comparison among different modes of drying hands after handwashing as used by the respondents of the study. It is observed that most of the people used towel followed by tissue or auto dryer before the pandemic period. However, during the current pandemic, the use of tissues and towel are found to be significant as compared to other modes of hand drying. The use of paper towels, followed by warm hand dryers, jet hand dryers and cloth towel rolls were observed as the most often adopted methods in Hong Kong before the COVID-10 outbreak (Suen et al., 2019). However, the differences in adopting methods of hand drying in Bangladesh may be ascribed to the unavailability of specific drying facilities or due to the differences in socio-economic status between the two countries. In a cross-sectional study in United States, Marcenac et al. (2021) observed increased choice for using electric hand dryers, wiping hands on cloth, and shaking hands in public bathrooms. However, people showed decreased preference for using paper towels in the COVID-19 pandemic as compared to the pre-pandemic situation. This might be ascribed to the fact that respondents in the study wanted to avoid contacting coronavirus 2 (SARS-CoV-2) while they touched surfaces in public bathrooms. However, improper methods of hand drying might spread bacteria in real-world settings (Best et al., 2018). The effectiveness of a specific

![Fig. 9. Use of different modes to dry hands.](image-url)

![Fig. 8. Variation in the usage of disinfectants with income of respondents.](image-url)
3.4. Water consumption pattern with the changed handwashing practices in the pandemic

The habits of peoples’ handwashing with soap and water have been observed to be changed significantly around the world since the outbreak of COVID-19. The changed situation has also influenced the daily water consumption pattern of an individual. The water consumption for handwashing during pre-pandemic, pandemic and post-pandemic situation and at various frequencies has, therefore, been estimated in the study, and is depicted in Fig. 10. The figure shows the total water requirement for the respondents according to their reported variations in handwashing frequencies during pre-corona, during corona and post-corona period. In this study, about 90% of the respondents used supply water for their handwashing. A very little fraction (6%) is seen using tube well as their water source, while 4% of the respondents have no such option and depended on stored water for handwashing. The overall estimated water demand in corona and post-corona has been increased to 3360 L/d and 3150 L/d, respectively, which was only 1250 L/d in the pre-corona period for a total of 367 participants having different handwashing frequencies. The overall daily water consumption for every individual is estimated to be 2.68 times (9.15 L/c/d) and 2.52 times (8.59 L/c/d) higher in corona and post-corona, respectively, than that of the pre-corona situation (3.41 L/c/d). The average increase in water consumption is much lower than the findings of a cross-sectional web-based study by Sayeed et al. (2021). They have found that 57.3% of the respondents kept their tap on throughout the handwashing process including lathering with soap and consequent hand scrubbing for 18s which has raised the overuse of water by 13-fold (14.9 L: 1.7 L) during this pandemic period as compared to the non-pandemic situation. This significant difference between the two studies might be ascribed to various handwashing frequencies, different water requirement for each wash and minimum duration of wash considered in the current study. Nevertheless, the average increase in water consumption due to current pandemic might cause an extra amount of 30.5 BDT (around 0.36 $) per day for the total 367 participants. The estimated extra cost is much lower than the estimated amount by Sayeed et al. (2021) which might be due to the different valuation of water for different geographic locations.

However, both studies have considered the use of running water during individual’s handwashing with soap including the time for lathering with soap and subsequent scrubbing of hands. A lesser amount of water would be required for handwashing if people become more aware to reduce wastage of water by switching the tap off during lathering process and during the time of scrubbing hands with soap. People should be educated to reduce wastage of water during the handwashing process since the potable water sources are somewhat constrained and overstretched in the country. The surface water source of the country is being polluted by various unregulated discharges, and the groundwater, in some areas, carries toxic metals above the recommended levels for drinking. Moreover, the water sources are facing the challenges of salinity intrusion due to the climate change especially in the coastal areas. Furthermore, the over extraction of groundwater over the past years has resulted in significant decline in the country, and the groundwater level is being lowered at a rate of more than 3 m in Dhaka city (Khan et al., 2016; Sayeed et al., 2021). In these circumstances, the increased rate of water consumption evaluated in the study gives an indication that the country may face the challenges of shortage in potable water supply. As a consequence, the country may face challenges of attaining sustainable development goals of the country. Sayeed et al. (2021) recommended for the provision of automated system instead of manually operated water tap, alcohol-based gel to sanitize hands as an alternative to wash hands with soap and water to overcome the challenges. However, automated system might not be a cost-effective option for the low-income countries like Bangladesh except in high-income settlements and in public places with the provision of government subsidies. Occasional use of any hand sanitizer could be helpful in case of the unavailability of water and soap. Raising more awareness regarding health safety and hand hygiene, and educating people about sensible water usage during the handwashing process would be effective in this regard to reduce wastage of water as well as to minimize the costs of water.

3.5. Association between individual’s socio-demographic factors and handwashing practice

Factor analysis using PCA has been conducted in order to evaluate the weightage associations among different variables including socioeconomic data, variable responses or perceptions of the respondents in relation to handwash practices during pre, post and corona periods. Islam et al. (2020) used the method to investigate the interface between the respondent’s perception and determinant related to WASH and waste disposal practices among residents of Bangladesh during the current pandemic. In the study of Islam et al. (2020), a total of 5 factors or principal components (PCs) were extracted from PCA, which represent 63.831% of the total variance and eigenvalues greater than 1. PCA identified four principal components having eigenvalues greater than 1 in this study of which the cumulative percentage of variance of studied data are 61.50% which is closer to the study results reported by Islam et al. (2020). In this alignment, the scree plot has also been considered to categorise the number of principal components (PCs) to be retained based on the importance and biasedness of different parameters. The component plot in rotated space and the estimated factor loadings are presented in Fig. 11 and Table 4, respectively. As seen in Table 4, the standing of the components with their respective loadings of variance are PC 1 with 19.74%, PC 2 with 17.84%, PC 3 with 15.33%, and PC 4 with 8.60% (PC4).

Among the components, the PC1 encompasses the socioeconomic variables of age (X2) and income (X5), and moderate positive loadings with education (X3) and occupation (X4) that are commonly reflected as very important aspects of the responses in this type of assessment. As the duration of handwash is strongly guided by different health organizations worldwide, the PC2 mainly is seen to be found with relatively high loadings for duration of handwashing in corona period (X10) and in post-corona period (X11), and with a moderate loading with hygiene education (X7), COVID-19 outbreak (X8). This association illustrates the fact that all these variables are associated with health hygiene. The PC3 elucidated with both negative and positive high loadings of frequencies defying the negative association with number of times of handwash...
The analysis therefore, has been carried out for the corona period only, minimum time of hand rubbing with soap during the current pandemic. Post-corona imply that the outbreak of corona virus has strong influence on the proper practice of individual hand hygiene. Since the duration of handwashing has strong loadings in PCA, and is very important to eliminate different viruses and bacteria completely from hands, regression analysis has been performed further to assess the surrogate parameters influencing the reported duration of handwashing practices. The general intention of people is found more aligned with the importance of good quality water availability in nearby sources. However, high loadings in corona and post-corona imply that the outbreak of corona virus has strong influence on the proper practice of individual’s hand hygiene.

Since the duration of handwashing has strong loadings in PCA, and is very important to eliminate different viruses and bacteria completely from hands, regression analysis has been performed further to assess the surrogate parameters influencing the reported duration of handwashing practices. The general intention of people is found more aligned with the minimum time of hand rubbing with soap during the current pandemic.

The analysis therefore, has been carried out for the corona period only, and the findings of the analysis is tabulated in Table 5. In this study, most of the socio-demographic variables of participants were found statistically insignificant for the duration of handwashing during the corona period in both the univariate analysis and multivariate analysis. This is due to the fact that the duration of handwash is more applicable to the people having required commodities such as water, soap, sanitizers, purchasing capacity, and above all awareness through hygiene education. In this align, the influence of hygiene education and COVID-19 outbreak have, as discussed, been found highly significant (p-value < 0.001) implying their significant influences on the duration of handwashing for both the analyses. It is found in this study that 62.1% (228) of the respondents have received hygiene education at various level of their academic education. Only 41% (95 of those 228) of those who received the education perceived that their education was adequate to help them fight against the coronavirus. Proportions of respondents received hygiene education were higher in (i) individuals aged less than 18 years vs. more than 50 years (75.0% vs. 40.0%, p = 0.002) and (ii) medical persons vs. unemployed (75% vs. 38.5%, p = 0.002). The descriptive statistics of this study for all the variables associated with hygiene education are presented in Table 6. Proportions of respondents having satisfaction of education received in this regard were higher in individuals of medical professions vs. private employees (75% vs. 13.5%, p = 0.007). However, 97.3% of the total participants of this study suggested to include adequate and proper hygiene education in their academic curricula from elementary school.

To extend analysis in this issue, logistic regression analyses, as presented in Table 7, were also conducted in the study. In this analysis most of the variables influencing the status of hygiene education were found to be statistically significant. Individuals between the ages of 18 and 24 were 0.04 times less likely than the respondents aged more than 50 years to include hygiene education in curriculum (OR = 0.04; 95% CI = 0–0.31, p = 0.002). Female respondents were 0.56 times satisfied with their academic education. Only 41% (95 of those 228) of those who received the education perceived that their education was adequate to fight against COVID-19. The students and academicians were found to be more likely than the others giving their consent to include hygiene education in academic curriculum (OR = 0.34–0.92, p = 0.02) to fight against COVID-19. The students and academicians were found to be more likely than the others giving their consent to include hygiene education in academic curriculum, and affirming their received education was not adequate to preventing the current pandemic. Many studies showed that people having hygiene knowledge may protect themselves and their families in a more effective way from infectious diseases than others who lack the knowledge (Nanan et al., 2003; Sandora et al., 2005; Kelčiková et al., 2012). Schools are crucial for the physical and cognitive developments of children, and can be critical locations for limiting as well as for spreading of various transmissible diseases such as gastrointestinal diseases, respiratory infections, including COVID-19 (Patel et al., 2012; Munn et al., 2020; Anthonj et al., 2021). In a school-based study in Kenya by Patel et al. (2012), students were observed with sustained progress in hygiene practices.
related knowledge and a reduced risk of respiratory infections after the inclusion of hygiene education in curriculum and installations of water stations in schools. Another study by Sudjana et al. (2016) found a strong association between knowledge and personal hygiene practices, and positive attitudes towards hygiene practices among school students in Indonesia. Moreover, pre-primary education and WASH have got preferences within the global Sustainable Development Goals (SDG). Yield of remarkable short and long-term advantages for older children, their families and the whole community from the evidence of school-based hygiene programs justify its necessity in early childhood settings (Wagnar and Samuelsson 2019). However, most of the hygiene education related curricula in the country, are generally emphasised on maintaining personal hygiene to stay safe from communicable diseases. It is noteworthy to mention that washing hands before and after having meals and after defecation regarding hand hygiene were the main issue of discussion rather than the proper duration and frequency of handwashing to fight against communicable diseases. The behaviours and attitude towards health hygiene are not the issues of teaching or learning in schools only, but it is equally important to realize the education in regular practices for a healthy living. It is, therefore, recommended that the basic hygiene education should be taught from the primary education level to make it functionally better for maintaining health and hygiene of an individual. However, the messages regarding proper and adequate handwashing from international and national organizations have been disseminated among people during the pandemic mainly through TV news. Various social media, newspaper etc. have also played a critical role in this regard. This is often neglected particularly in the developing countries due to various reasons which requires special attention. Therefore, guidelines for proper handwashing strategies should be incorporated in academic curriculum at any level to achieve sustainable goals number six (06) set for the signatory countries like Bangladesh.

4. Limitations of Study

The study has limitations in various ways. Firstly, this has been conducted through an online questionnaire survey which was distributed among the residents of Bangladesh via social media. Therefore, only those who have internet access, and are familiar with this type of survey participated in this research. This has brought about an uneven geographical distribution of sampling population in this study. Moreover, the frequency and duration of handwashing were self-reported by the respondents, and associated water consumption was evaluated based on that reported information without any actual observation in the field level. Hence there may be either overestimation or underestimation of water consumption compared to the actual case. However, during the COVID-19 pandemic with the countrywide strict lockdown situation, this type of online-based survey was the most convenient and practicable option for data collection. Nevertheless, this study presents the perception and handwashing behaviour of general people to protect themselves from any communicable disease even from the deadly COVID-19. Further evaluation through nationwide field-scale research is recommended to design effective interventions for hygiene promotion and the sustainable water management of the country.

Table 5

| Variables | Univariate analysis | Multivariate analysis |
|-----------|---------------------|----------------------|
|           | OR 95% CI p-value   | OR 95% CI p-value    |
| Gender    |                     |                      |
| Male      | 1                   | 1                    |
| Female    | 1.09 (0.48-2.48) 0.85 | 1.11 (0.44-2.79) 0.83 |
| Age       |                     |                      |
| <18       | 1                   | 1                    |
| 18-24     | 1.54 (0.17-14.36) 0.72 | 1.28 (0.23-8.18) 0.78 |
| 25-50     | 2.31 (0.24-22.1) 0.48 | 1.69 (0.31-11.23) 0.62 |
| >50       | 2.25 (0.11-45.7) 0.61 | 2.31 (0.13-23.12) 0.48 |
| Education |                     |                      |
| SSC or below | 1               | 1                    |
| HSC       | 0.69 (0.08-5.84) 0.73 | 1.24 (0.13-12.07) 0.86 |
| Graduate  | 0.61 (0.07-4.98) 0.64 | 0.66 (0.07-5.97) 0.71 |
| Postgraduate | 0.67 (0.08-5.91) 0.72 | 0.64 (0.06-6.77) 0.71 |
| Others    | 0.87 (0.12-6.32) 0.68 | 0.82 (0.24-6.89) 0.66 |
| Occupation|                     |                      |
| Student   |                     |                      |
| 1         | 1                   | 1                    |
| 2         | 1.39 (0.45-4.25) 0.57 | 3.58 (0.17-75.37) 0.41 |
| 3         | 2.41 (0.8-7.22) 0.12 | 6.44 (0.36-115.28) 0.21 |
| 4         | 2.53 (0.57-11.25) 0.22 | 4.25 (0.16-115.94) 0.39 |
| 5         | 1.89 (0.67-14.56) 0.78 | 3.43 (0.82-45.67) 0.45 |
| 6         | 0.89 (0.13-7.53) 0.21 | 0.92 (0.12-11.34) 0.31 |
| 7         | 0.26 (0.08-0.86) 0.03 | 0.52 (0.09-33) 0.46 |
| Income    |                     |                      |
| <10000    |                     |                      |
| 10000-25000 | 0.88 (0.24-3.23) 0.84 | 0.79 (0.17-3.8) 0.77 |
| 25000-50000 | 2.89 (0.97-8.6) 0.05 | 1.05 (0.06-18.29) 0.97 |
| 50000-75000 | 2.37 (0.53-10.54) 0.26 | 0.84 (0.05-14.82) 0.92 |
| 75000-100000 | 0.82 (0.22-3.04) 0.76 | 0.21 (0.01-3.12) 0.26 |
| >100000   | 2.45 (0.31-19.44) 0.41 | 0.61 (0.02-14.91) 0.76 |
| Source of Water |                  |                      |
| Tap Water/Supply Water | 1          | 1                    |
| 1         |                     |                      |
| 2         | 4.08 (0.54-30.89) 0.17 | 4.74 (0.58-38.68) 0.15 |
| 3         | 0.27 (0.09-0.84) 0.02 | 0.32 (0.15-1.27) 0.07 |
| Received Hygiene Education |                |                      |
| Yes       |                     |                      |
| 1         |                     |                      |
| No        | 0.07 (0.03-0.12) <0.001 | 0.33 (0.16-0.71) 0.004 |
| Known About the Outbreak |               |                      |
| Yes       |                     |                      |
| 1         |                     |                      |
| No        | 0.06 (0.02-0.16) <0.001 | 0.43 (0.24-1.55) 0.025 |
5. Conclusion

Handwashing plays a critical role to prevent the spread of any infectious disease, and it has gained special attention during the coronavirus pandemic. The study has been conducted to evaluate the knowledge, awareness, and practices of hand hygiene during the pandemic based on the findings of an online survey conducted among the residents of Bangladesh. The three different cases such as pre-corona, during corona, and post-corona period were used in the study to compare the changes in the pattern of hand hygiene practices due to the outbreak of COVID-19. A total of 367 participants with different socioeconomic status attended the survey from different parts of the country. Almost all (97.7%) of the participants are found to be well-informed about coronavirus 2, and 78.2% are concerned of various preventive measures against the virus. The study revealed that most of the people have had the basic knowledge to maintain hand hygiene to keep themselves safe from any transmissible disease such as the COVID-19. Social media deserves appreciation for the widespread dissemination of information regarding hand hygiene. The level of practices, however, were found to be very poor before the COVID-19 pandemic situation. The severity of current pandemic has imposed people to wash their hands more frequently than they used to do before. Consequently, the overall water demand for washing hands has been increased by 169% during the corona period compared to that in the pre-corona period. Moreover, it is perceived that the increased demand of water might continue in future and may rise by 152% when the pandemic comes to an end. Valuing water properly, this is equivalent to an extra cost of 30.5 BDT (around 0.36 $) per day for a total of 367 respondents of the study. The changes in the usage of disinfectants such as hand sanitizers are also found to be remarkable for complete disinfection of hands.

Principal Component Analysis (PCA) and regression analysis have been performed to investigate the association between socioeconomic characteristics of the respondents and their handwashing practices. It has been found that an individual’s practice of handwashing is somewhat associated with income, level of academic education, hygiene education, COVID-19 outbreak. However, high loadings in case of corona and post-corona periods imply that the outbreak of coronavirus has a high correlation with the proper practice of individual’s hand hygiene. Moreover, it is found from the regression analysis that the influence of hygiene education is highly significant (p-value < 0.001) to control the proper duration of the handwashing process. According to the study, 62.1% (228) of the participants acquired basic hygiene education from their academic curriculum. However, 41% of that 62.1% participants reported that their previous knowledge on hygiene practices were not enough to help fight against COVID-19. Furthermore, almost all (97.3%) of the respondents expressed their opinions to include hygiene education in the curriculum at any level of education as they believed that it played a crucial role to prevent COVID-19 and other diseases as well. Most of the hygiene-related curricula in this country covers personal hygiene to keep people safe from communicable diseases. Regarding the hand hygiene, major focus has been given on washing hands before and after having meals, and after defecation without any specific consideration given on frequency and duration of handwashing. Recently, TV news, various social media, newspapers etc. have played critical role to disseminate the regulations of washing hands with soap for at least 20–30s or sanitizing with alcohol-based disinfectants whenever it is required to prevent infections from coronavirus or other communicable diseases. Therefore, guidelines for proper handwashing strategies should be incorporated in the academic curriculum at any level of education to achieve sustainable goals set for any country.

| Table 6 Distribution of variables and their association with hygiene education. |
|------------------|------------------|------------------|------------------|
| Variables        | Total N = 367    | Received Hygiene Education | Inclusion of Hygiene Education | Received Education to Date Applicable to Fight against COVID-19 |
|                  | N (%)            | Yes (%) | X² | df | p-value | Yes (%) | X² | df | p-value | Yes (%) | X² | df | p-value |
| Gender           |                  |         |    |    |         |         |    |    |         |         |    |    |         |
| Male             | 277 (75.5)       | 172 (61.2) | 0.0004 | 1 | 0.984 | 269 (97.1) | 0.114 | 1 | 0.736 | 70 (25.3) | 5.234 | 1 | 0.022 |
| Female           | 90 (24.5)        | 56 (62.2) |     |    |         | 88 (97.8) |     |    |         | 34 (37.8) |     |    |         |
| Age              |                  |         |    |    |         |         |    |    |         |         |    |    |         |
| <18              | 04 (1.1)         | 03 (75.0) | 15.412 | 3 | 0.002 | 03 (75.0) | 188.9 | 3 | <0.001 | 03 (75.0) | 31.461 | 3 | <0.001 |
| 18-24            | 175 (47.7)       | 126 (72.0) |     |    |         | 45 (25.7) |     |    |         | 71 (40.6) |     |    |         |
| 25-50            | 178 (48.5)       | 95 (53.4) |     |    |         | 170 (95.5) |     |    |         | 28 (15.7) |     |    |         |
| >50              | 10 (2.7)         | 04 (40.0) |     |    |         | 09 (90.0) |     |    |         | 02 (20.0) |     |    |         |
| Education        |                  |         |    |    |         |         |    |    |         |         |    |    |         |
| SSC or below     | 03 (0.8)         | 02 (66.7) | 4.044 | 4 | 0.401 | 02 (66.7) | 11.59 | 4 | 0.021 | 02 (66.7) | 35.712 | 4 | <0.001 |
| HSC              | 95 (25.9)        | 63 (66.3) |     |    |         | 91 (95.8) |     |    |         | 18 (18.9) |     |    |         |
| Graduate         | 165 (45.0)       | 106 (64.2) |     |    |         | 161 (97.6) |     |    |         | 70 (42.4) |     |    |         |
| Post-graduate    | 91 (24.8)        | 49 (53.8) |     |    |         | 89 (97.8) |     |    |         | 12 (13.2) |     |    |         |
| Others           | 13 (3.5)         | 08 (61.5) |     |    |         | 12 (92.3) |     |    |         | 02 (15.4) |     |    |         |
| Occupation       |                  |         |    |    |         |         |    |    |         |         |    |    |         |
| Student          | 191 (52.0)       | 136 (71.2) | 21.461 | 6 | 0.002 | 184 (96.3) | 20.84 | 6 | 0.002 | 58 (30.4) | 17.804 | 6 | 0.007 |
| Academician      | 44 (12.0)        | 25 (56.8) |     |    |         | 43 (97.7) |     |    |         | 14 (31.8) |     |    |         |
| Pvt. Employee    | 74 (20.2)        | 33 (44.6) |     |    |         | 73 (98.6) |     |    |         | 10 (13.5) |     |    |         |
| Govt. Employee   | 39 (10.6)        | 26 (66.7) |     |    |         | 38 (97.4) |     |    |         | 12 (30.8) |     |    |         |
| Medical Person   | 04 (1.1)         | 03 (75.0) |     |    |         | 03 (75.0) |     |    |         | 03 (75.0) |     |    |         |
| Business         | 02 (0.5)         | 01 (50.0) |     |    |         | 01 (50.0) |     |    |         | 01 (50.0) |     |    |         |
| Unemployed       | 13 (3.6)         | 05 (38.5) |     |    |         | 12 (92.3) |     |    |         | 06 (46.2) |     |    |         |
| Received Hygiene Education | |         |    |    |         |         |    |    |         |         |    |    |         |
| Yes              | 228 (62.1)       | 228 (100) |     |    |         | 224 (98.2) | 2.139 | 1 | <0.001 | 95 (41.7) | 52.664 | 1 | <0.001 |
| No               | 139 (37.9)       | 0 (0.0) |     |    |         | 133 (95.7) |     |    |         | 09 (6.5) |     |    |         |
| Inclusion of Hygiene Education | |         |    |    |         |         |    |    |         |         |    |    |         |
| Yes              | 357 (97.5)       | 224 (62.7) | 2.139 | 1 | 0.144 | 357 (100) |     |    |         | 99 (27.7) | 2.375 | 1 | 0.123 |
| No               | 10 (2.7)         | 0 (0.0) |     |    |         | 0 (0.0) |     |    |         | 05 (50.0) |     |    |         |
| Received Education to Date Applicable to Fight against COVID-19 | |         |    |    |         |         |    |    |         |         |    |    |         |
| Yes              | 104 (28.3)       | 95 (91.3) | 52.664 | 1 | <0.001 | 99 (95.2) | 2.375 | 1 | 0.123 | 104 (100) |     |    |         |
| No               | 263 (71.7)       | 133 (50.6) |     |    |         | 258 (98.1) |     |    |         | 0 (0.0) |     |    |         |
Table 7
Regression analysis of variables by hygiene education, inclusion and adequacy of the education.

| Variables               | Received Hygiene Education | Inclusion of Hygiene Education | Received Education to Date Applicable to Fight against COVID-19 |
|-------------------------|---------------------------|--------------------------------|---------------------------------------------------------------|
|                         | OR 95%CI | p-value | OR 95%CI | p-value | OR 95%CI | p-value |
| Gender                  |          |         |          |         |          |         |
| Male                    | 0.99 (0.61–1.62) | 0.984 | 0.76 (0.16–3.67) | 0.751 | 0.56 (0.34–0.92) | 0.023 |
| Female                  | 1         | 1       | 1        | 1       | 1        | 1       |
| Age                     |          |         |          |         |          |         |
| <18                     | 4.5 (0.34–60.15) | 0.258 | 0.33 (0.02–7.14) | 0.492 | 12 (0.77–186.37) | 0.075 |
| 18–24                   | 3.86 (1.04–14.26) | 0.043 | 0.04 (0–0.31) | 0.002 | 2.73 (0.56–13.24) | 0.214 |
| 25–50                   | 1.72 (0.47–6.29) | 0.426 | 2.36 (0.26–19.16) | 0.429 | 0.75 (0.15–3.62) | 0.729 |
| >50                     | 1         | 1       | 1        | 1       | 1        | 1       |
| Education               |          |         |          |         |          |         |
| SSC or below            | 1.25 (0.09–17.65) | 0.878 | 0.17 (0.01–3.89) | 0.268 | 11 (0.65–187.3) | 0.097 |
| HSC                     | 1.23 (0.37–4.07) | 0.747 | 1.9 (0.2–18.4) | 0.593 | 1.29 (0.26–6.32) | 0.769 |
| Graduate                | 1.12 (0.25–5.92) | 0.855 | 3.35 (0.35–32.42) | 0.298 | 4.05 (0.87–18.87) | 0.071 |
| Post-graduate           | 0.73 (0.22–2.4) | 0.606 | 3.71 (0.38–35.84) | 0.261 | 0.84 (0.18–3.89) | 0.831 |
| Others                  | 1         | 1       | 1        | 1       | 1        | 1       |
| Occupation              |          |         |          |         |          |         |
| Student                 | 3.96 (1.24–12.63) | 0.201 | 2.19 (0.25–19.28) | 0.489 | 0.51 (0.16–1.58) | 0.245 |
| Academician             | 2.11 (0.59–7.47) | 0.252 | 3.58 (0.28–61.62) | 0.386 | 0.54 (0.15–1.92) | 0.351 |
| Pvt. Employee           | 1.29 (0.38–4.31) | 0.694 | 6.08 (0.36–103.94) | 0.214 | 0.18 (0.05–0.65) | 0.009 |
| Govt. Employee          | 3.2 (0.87–11.75) | 0.071 | 3.17 (0.18–54.57) | 0.436 | 0.52 (0.14–1.87) | 0.321 |
| Medical Person          | 4.8 (0.38–59.89) | 0.225 | 0.25 (0.01–5.26) | 0.379 | 3.51 (0.28–43.16) | 0.333 |
| Business                | 1.6 (0.13–19.97) | 0.728 | 0.08 (0.04–1.75) | 0.109 | 1.17 (0.09–14.38) | 0.912 |
| Unemployed              | 1         | 1       | 1        | 1       | 1        | 1       |
| Received Hygiene Education |        |         |          |         |          |         |
| Yes                     | –        | –       | –        | 2.53 (0.7–9.12) | 0.175 | 10.3 (4.99–21.31) | <0.001 |
| No                      | 1         | 1       | 1        | 1       | 1        | 1       |
| Inclusion of Hygiene Education |        |         |          |         |          |         |
| Yes                     | 2.53 (0.7–9.12) | 0.175 | –        | –        | –        | 0.38 (0.11–3.35) | 0.137 |
| No                      | 1         | 1       | 1        | 1       | 1        | 1       |
| Received Education to Date Applicable to Fight against COVID-19 |        |         |          |         |          |         |
| Yes                     | 10.3 (4.99–21.31) | <0.001 | 0.53 (0.7–9.12) | 0.175 | –        | –        |
| No                      | 1         | 1       | 1        | 1       | 1        | 1       |

Most of the respondents used supply water for handwashing, and the study reasonably considered that the water tap was kept on during the whole handwashing process including the time of hand rubbing with soap and lathering. If people become aware to turn the tap off at least during the lathering process, the rate of water consumption might be far less than the current rate of consumption. The increased rate of water consumption at the current state of handwashing practice is indicative of the fact that the water supply versus demand might become scanty, and the country may face enormous pressure in near future, especially in over populated urban settings of the country. Therefore, the sustainability of practices to maintain hand hygiene may be hampered if people do not change their current attitudes and behaviors in this regard.

Global water demand has been significantly increased over the last few years which might be ascribed to unexpected population growth, unplanned industrial development, and certainly due to the changes in water consumption patterns. The current COVID-19 pandemic has additionally brought about a remarkable change in the individual’s habits of handwashing all over the world which certainly has also increased overall water demand. Nevertheless, hand hygiene is one of the preventive and effective measures to safeguard public health against contagious diseases which cannot be compromised during the current pandemic situation. Moreover, washing hands with least water usage is imperative to reduce the stress on water supply in countries like Bangladesh where freshwater resources are either limited or somewhat constrained. Therefore, revising the academic curriculum to incorporate effective and appropriate educational contents to valuing water, raising awareness towards individual’s behavioral change are indispensable to minimize water usage during the handwashing process. Public health campaigns, various community-oriented training programs, and provision of subsidies for changes in the process of operating tap during handwashing such as automatic or sensor-based systems instead of manual systems, occasional use of hand sanitizer might also be considered worthwhile strategies for developing countries like Bangladesh to ensure healthy living with sustainable management of water resources.

Ethical considerations

The study got the ethical clearance from the concerned authority of CUET for undertaking research. They were instructed on the nature of the survey and were given ample input about how to respond to the questionnaire prior to the survey. In addition, confidentiality, right of withdrawal, approval, and voluntary participation details were also mentioned.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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