Knowledge on and preventive practices of cholera in Al-Mahweet – Yemen, 2018: a cross-sectional study

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ABSTRACT

Yemen has experienced one of the world’s worst cholera outbreaks in the recent history of cholera records. This study aims to identify knowledge and practices among people of Al-Mahweet governorate toward cholera infection, which can play a critical role in reducing cholera morbidity and shaping the public health response. A cross-sectional study was conducted in an area of high cholera prevalence in 2018 using structured questionnaires. Most community respondents were able to correctly identify the symptoms and risk factors of cholera. While 65% of the respondents in this study knew that proper disposal of human waste is an essential measure of cholera prevention, only 11% of the respondents knew that proper washing of fruits and vegetables lowers the risk of cholera infection. About 62.5% of households did not treat water for safe drinking. Water was scarce in about 30% of households and near-home defecation was observed in about 23%. In conclusion, this study reveals several gaps in different aspects of hygienic and preventive practices including water treatment, waste disposal, and defecation practices. Cholera response should contain comprehensive health promotion interventions to improve the public’s knowledge and enhance healthy practices. Stakeholders should support communities with sustainable water and sanitation systems.

Key words: cholera, WASH, water and sanitation, Yemen

INTRODUCTION

Cholera is a waterborne, life-threatening diarrheal infection caused by a bacterium called Vibrio cholerae, a highly diverse species divided into more than 200 serogroups (Momba & Azab El-Liethy 2019). The transmission can take place either through a fecal–oral route or through direct infection from the environment. Few cases of cholera infections develop mild to moderate symptoms present as mild acute watery diarrhea (AWD) that can be managed with oral rehydration solutions (ORS). Almost 20% of symptomatic cases are severe with abrupt onset of profuse watery diarrhea and dehydration that, if untreated, can lead to death (World Health Organization 2016). Cholera continues to be a significant threat to global public health with an estimated 2.86 million cases and 95,000 associated deaths occurring annually, of which, only a fraction is reported due to inadequate surveillance systems and inconsistencies in case definitions as well as economic, political, and social disincentives (Ali et al. 2015). Globally, cholera is currently prevalent in Africa, Asia, and parts of the Middle East, where Yemen reported recently the most cholera cases in a single country (World Health Organization 2018).

Yemen is located in southwest Asia on the Arabian Peninsula. The country has a diverse topography ranging from desert in the east, mountains in the north, and a coastal landscape in the south and the west. Yemen is divided officially into 23
governorates and 333 districts with a total population of 31.5 million and a 3.9% population growth rate, which is one of the highest rates worldwide (Yemen | Institute for Health Metrics and Evaluation 2021). Yemen is the poorest country in the region, ranking 177 out of 189 countries in the Human Developmental Index (HDI) in 2018 (UNDP 2019) and ranked number 1 in the Fragile State Index in 2019 with a score of 113.5 (the maximum is 120) (The Fund for Peace 2021).

A critical situation of political instability has been created since the Arab Spring in 2011. In March 2015, a widespread armed conflict emerged in the country resulting in the worst humanitarian crisis in the world. Since then, many epidemics have erupted in the country, including a massive outbreak of cholera. In October 2016, the first wave of cholera occurred without reaching an alarming level, but then spiked to a higher level in April 2017 with more than 1.1 million suspected cases (Camacho et al. 2018; WHO 2018). The WHO reported a cumulative total of 1,115,378 suspected cholera cases and 2,310 associated deaths, corresponding to a CFR of 0.21% from 2017 to 1 July 2018 (WHO 2018).

Different factors fuel cholera in Yemen. A recent study suggested an association between weekly rainfall and suspected cholera incidence (Camacho et al. 2018). Another study identified the use of common-source water, not having washed fruits, vegetables, and khat, and not using chlorine or soap in the household as important risk factors of cholera (Dureab et al. 2019). The ongoing war in Yemen has caused significant destruction to essential infrastructure, including water and sanitation systems and health facilities, leaving 24.1 million people in need of some sort of humanitarian or protection assistance, including almost 17.8 million people who lack adequate access to clean water, sanitation, and hygiene (OCHA 2018). The collapse of infrastructure combined with economic decline, high prevalence of severe food insecurity, malnutrition, and poor community-level awareness on basic hygiene and sanitation practices have depressed overall resilience towards cholera (Oxfam 2017; World Bank Group 2017; WASH Cluster 2020). Hence, the war has created a fertile ground for cholera, facilitating the largest outbreak in epidemiologically record history (Oxfam 2017; Federspiel & Ali 2018; Blackburn et al. 2020).

In response to this outbreak, WHO and Water, Sanitation, and Hygiene (WASH) cluster developed an integrated response plan including the establishment of cholera treatment centers, expanded disease surveillance capacity, WASH interventions, and education campaigns to address and prevent further spread of the outbreak in the 286 high-risk districts (WHO and WASH Cluster 2017).

Evidence has suggested that education campaigns and information transmission have an important effect in reducing the prevalence of infections (Kiss et al. 2010; Yang et al. 2017). A review of the literature revealed a positive effect of awareness interventions to control cholera (Taylor et al. 2015). One study suggested that the public health messages were effective and promoted behavioral changes related to cholera prevention (Aibana et al. 2013). There is a lack of knowledge and practice studies on cholera among Yemeni people. Al-Sakkaf et al. (2020) found suboptimal knowledge of cholera transmission and prevention among populations in Aden. Community knowledge and practice studies during outbreaks assist in identifying knowledge and behavior that can play a critical role in lowering exposure to infectious agents and thus the cholera morbidity and in shaping appropriate public health response. This study aims to identify knowledge and practice of local populations in Al-Mahweet governorate in Yemen toward cholera infection.

**METHODOLOGY**

**Study design**

This is a descriptive cross-sectional study, which presents a ‘snapshot’ of specific characteristics of a condition in a population at a particular time point, to evaluate the public’s knowledge and practices in a rural governorate in Yemen – Al-Mahweet.

**Description of study area**

Al-Mahweet is a mountainous governorate situated north west of Sana’a. With a total population of 718,683, it covers 2,330 km². It is divided administratively into 9 districts, 115 Ozla, and 1,264 villages. It contains 179 health facilities including 1 general hospital, 5 district hospitals, 11 health centers, and 155 health facility units.

Al-Mahweet is among the five governorates that have the highest accumulative attack rate with 80,578 reported cholera cases and 181 deaths from April 2017 to December 2018 (WHO 2019). A review of WASH assessment in Yemen revealed that access to adequate sanitation in Al-Mahweet was the lowest among assessed governorates, where some districts in Al-Mahweet had access rates between 0 and 14%. Additionally, only 20% of assessed populations in Al-Mahheet districts had access to sufficient water quantities (WASH Cluster 2020).
Sample size
We calculated the sample size of 384 households using the following parameters: population size of 282,664, 5% confidence limits, 95% confidence level, and the expected frequency of the outcome was considered at 50%. However, the final sample size after processing the data was 352.
As the study area is a kind of hidden population with no population sampling frame, a total of 352 households’ caregivers were enrolled through multistage-cluster sampling. During the first stage, 7 districts were purposively selected because they were accessible. Out of the 7 districts, 16 clusters were randomly selected proportional to the size; some districts contributed one cluster while others two or three clusters. A total of 16 clusters (sub-district/village) around 16 targeted health facilities in the districts in Al-Mahweet governorate were selected (see Figure 1). Then, an equal number from each cluster was selected, that is, 22 households (HHs).

Ethical approval
Approval for conducting the study was obtained from the Ministry of Public Health and Population. Verbal consent was obtained from participants before conducting the interviews. The agreement to take part in the study indicates the participant’s consent.

Inclusion and exclusion criteria:

Inclusion criteria
• Being a caregiver for the selected household.
• People older than 15 years at the time of the study.
• Living in the selected village.
• Voluntarily agree to participate in the study.

Exclusion criteria
• Those who do not meet the inclusion criteria.

Figure 1 | Selected cluster map in Al-Mahweet governorate.
Data collection and validity

Data were collected from 25 to 29 June 2018 by a qualified team using structured pretested questionnaires conducted by face-to-face interviews. The assessment was based on the WHO and United Nations Children’s Fund (UNICEF) Joint Monitoring Programme for Water Supply and Sanitation (JMP) core questions on drinking water and sanitation for household surveys. Interviewers were trained before surveying to ensure that they understood the questionnaire well, and to avoid different interpretations of the concepts used. The questionnaire consists of socio-demographic characteristics, the history of diarrhea in the family, water sources, storage practices, handwashing, toilet type, cholera-related knowledge, and practices and exposure to health communication messages. In addition, it includes the observations related to the practices and hygienic conditions of the visited households that the surveyors captured while interviewing. Quality control measures were followed to ensure valid data; in this instance, all data collection was monitored and reviewed daily by a field team supervisor who regularly checked all questionnaires for completeness and accuracy. The overall data collection process was regularly supervised by a survey coordinator who monitored survey teams at frequent intervals.

Data analysis

Statistical Package for Social Sciences software (SPSS) version 22 was used, variables were presented as proportions, and standard deviations were used for data analysis.

RESULTS

Sociodemographic characteristics

A total of 352 households’ caregivers were enrolled during the study period and 7 districts were selected based on their accessibility. Out of these districts, 16 clusters were randomly selected proportional to the size.

Table 1 shows the main sociodemographic characteristics and history of morbidity and mortality of the study population. The age of caregivers/respondents ranged between 16 and 78 years with the mean age of 35.3 years and the median age of 34 years; about 78% of the respondents were between 20 and 49 years old. The majority of the respondents were female (94.3%). The average size of the households was 8 members (standard deviation (SD) = 4.3) and the mean number of children under 5 years was 1.2 (SD = 1.5). More than half of the respondents were illiterate (51%), 10% could read and write, about 22% of respondents had enrolled in primary education and only 17% had secondary or higher education.

Table 1 | Distribution of sociodemographic characteristics and history of morbidity and mortality of the study population

| Characteristics of households’ respondents | Number of households | Percentage |
|-------------------------------------------|---------------------|------------|
| Age group                                 |                     |            |
| <20                                       | 17                  | 4.8%       |
| 20–29                                     | 99                  | 28.1%      |
| 30–39                                     | 111                 | 31.5%      |
| 40–49                                     | 63                  | 17.9%      |
| 50–59                                     | 50                  | 14.2%      |
| 60+                                       | 12                  | 3.4%       |
| Sex                                       |                     |            |
| Male                                      | 20                  | 6.2%       |
| Female                                    | 332                 | 94.3%      |
| Household size                            |                     |            |
| <5                                        | 55                  | 15.6%      |
| 5–10                                      | 221                 | 62.8%      |
| >10                                       | 76                  | 21.6%      |
| Educational level                         |                     |            |
| Illiterate                                 | 180                 | 51.1%      |
| Primary education                         | 76                  | 21.6%      |
| Secondary education                       | 61                  | 17.3%      |
| Read and write                            | 35                  | 9.9%       |
| History of diarrhea illness among household members |   |            |
| Yes                                       | 144                 | 41%        |
| No                                        | 208                 | 59%        |
| History of death due to diarrhea among household members | |            |
| Yes                                       | 22                  | 6.3%       |
| No                                        | 330                 | 93.8%      |
About 41% of households’ members had a history of diarrhea in the past week (before the interview), the mean of ill patients in these HHs was 1.5 (1 SD) and for the children under five years old was 0.6 (0.684 SD). Around 6% of the households had lost at least one member due to diarrhea in the last year before the survey time; the mean number of deaths was one with (0.309 SD), under five child death mean of 0.41 (0.503 SD).

Characteristics related to water, sanitation, and hygiene (WASH)

Table 2 shows the main household’s WASH characteristics. The main source of drinking water was communal standpipe (38.1%) followed by spring water/unprotected (22%), and water truck (21.0%). Unavailability of water is a chronic problem facing 30% of HHs, particularly during the winter (January and February). Soap and detergent were available in 98% of the HHs, and the surveyors observed them in 90.3% of the HHs. They were used mainly for washing hands, washing clothes, cleaning utensils, and bathing. Half of the HHs have toilets in which water was poured for self-cleaning (siphon or bucket) to a well-covered pit, and about 23.9% of the HHs were using toilets in which water was poured for self-cleaning (siphon or bucket) to the outdoors. Only 2.6% of the HHs reported that they practiced open defecation; however, by observation, there was evidence of open defecation near the home in about 25% of HHs as shown in Table 3.

Table 2 | Distribution of WASH characteristics among the households

| Characteristics | Number of households | Percentage |
|-----------------|----------------------|------------|
| The main source of drinking water | | |
| Piped water, in house | 0 | 0.0% |
| Piped water, in-home yard | 0 | 0.0% |
| Piped water, public | 7 | 2.0% |
| Communal standpipe | 134 | 38.1% |
| Well, protected | 7 | 2.0% |
| Well, unprotected | 1 | 0.3% |
| Well with pump | 3 | 0.9% |
| Water truck/water vendor | 74 | 21.0% |
| River/stream/lake/irrigation canal | 21 | 6.0% |
| Bottled water/company for selling water | 1 | 0.3% |
| Rainwater | 17 | 4.8% |
| Spring water/unprotected | 79 | 22.4% |
| Other | 8 | 2.3% |
| The availability of soap or detergent in the house | | |
| Yes | 345 | 98.0% |
| No | 7 | 2.0% |
| The usage of the soap and detergent in the respondents’ house | | |
| Washing hands | 314 | 91.0% |
| Washing clothes | 315 | 91.3% |
| Cleaning home utensils | 305 | 88.4% |
| Bathing | 269 | 78.0% |
| For cleaning the home | 191 | 55.4% |
| Other | 1 | 0.3% |
| Kinds of toilets usually used by households | | |
| Toilet in which water is poured for self-cleaning (siphon or bucket) into the public sewer | 3 | 0.9% |
| Toilet in which water is poured for self-cleaning (siphon or bucket) to a well-covered pit | 178 | 50.6% |
| Toilet in which water is poured for self-cleaning (siphon or bucket) into a toilet bowl | 48 | 13.6% |
| Toilet in which water is poured for self-cleaning (siphon or bucket) to the outdoors | 84 | 23.9% |
| An improved toilet hole ventilated | 5 | 1.4% |
| A toilet hole covered with a board | 5 | 1.4% |
| Pit toilet without board/not covered | 2 | 0.6% |
| Compost latrine | 4 | 1.1% |
| Bucket toilet | 7 | 2.0% |
| Hanging toilet/hanging latrine | 7 | 2.0% |
| No toilets: Canal or open defecation/bush/field | 9 | 2.6% |
Surveyors also observed that there were containers to store drinking water in 90% of the HHs; about 97% of them have covered containers, 83% have a wide-mouthed opening and 71.6% have containers with a spigot/tap. Soap for washing hands was observed in 90% of HHs, while water and soap in the same location was observed in 78% of HHs. There was evidence of open defecation near the home in about 23% of HHs. The main roofing material for the household’s dwelling was wood for 67% and cement for 25% of the HHs. On the other hand, 81% of the HHs had their floor made from cement or tile/asbestos sheets (see Table 3).

### Education about cholera prevention and treatment

Ninety-seven percent of respondents were exposed to education regarding cholera in the past six months. The main source of information was community health workers in their villages (71.1%), clinician/healthcare worker (36%), and television (36.6%). The majority of the HHs (95.6%) received educational and hygienic materials as part of cholera prevention interventions: for instance, soap (94.1%), verbal information (73.5%), purification tablet (50.9%), and imprint educational material (46%) (Table 4).

### Knowledge about cholera

Table 5 summarizes the knowledge of respondents on cholera symptoms, risk factors’ prevention methods and treatment. The vast majority of respondents (99.4%) heard about cholera. Most of the respondents knew watery diarrhea (98.9%) and

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**Table 3** Distribution of WASH characteristics among the households (observational variables)

| Variables of observation                                | Number of households | Percentage |
|----------------------------------------------------------|----------------------|------------|
| Container to store drinking water?                       |                      |            |
| Yes                                                      | 320                  | 89.9%      |
| No                                                       | 32                   | 9.1%       |
| Container is:                                            |                      |            |
| Covered                                                  | 311                  | 97.2%      |
| Uncovered                                                | 9                    | 2.8%       |
| Container opening is:                                     |                      |            |
| Wide-mouthed (hand can fit in the opening)               | 266                  | 83.1%      |
| Narrow-mouthed (too small for a hand to fit through the opening) | 54                   | 16.9%      |
| The container has a spigot/tap:                          |                      |            |
| Yes                                                      | 229                  | 71.6%      |
| No                                                       | 91                   | 28.4%      |
| Is there soap in the house place for washing hands?      |                      |            |
| Yes                                                      | 315                  | 89.5%      |
| No                                                       | 34                   | 9.7%       |
| Unable to observe                                         | 3                    | 0.8%       |
| Are water and soap in the same location?                 |                      |            |
| Yes                                                      | 274                  | 77.8%      |
| No                                                       | 73                   | 20.7%      |
| Unable to observe                                         | 5                    | 0.5%       |
| Is there any evidence of open defecation near the home?   |                      |            |
| Yes                                                      | 80                   | 22.7%      |
| No                                                       | 237                  | 67.4%      |
| Unable to observe                                         | 35                   | 9.9%       |
| What is the main roofing material for the household’s dwelling? |              |            |
| Thatch                                                   | 2                    | 0.6%       |
| Metal/Iron sheets                                        | 2                    | 0.6%       |
| Tile/Asbestos sheets                                     | 0                    | 0.0%       |
| Wood                                                     | 235                  | 67.3%      |
| Cement                                                   | 86                   | 24.6%      |
| Other                                                    | 24                   | 6.9%       |
| What is the main flooring material                        |                      |            |
| Thatch                                                   | 0                    | 0.0%       |
| Metal/Iron sheets                                        | 0                    | 0.0%       |
| Tile/Asbestos sheets                                     | 62                   | 17.8%      |
| Wood                                                     | 8                    | 2.3%       |
| Cement                                                   | 220                  | 63.0%      |
| Earth/sand                                               | 47                   | 13.5%      |
| Other                                                    | 12                   | 3.4%       |
vomiting (93.1%) as symptoms associated with cholera followed by dehydration 28%, stomach/abdominal pain 21.7%, and fever 10.9%, respectively. The majority of respondents stated that drinking contaminated water (68.9%), eating contaminated food (79.7%) or unwashed fruits/vegetables (44.9%), and poor hygiene practices (62.9%) were the main risk factors of cholera.

Regarding the preventive measures of cholera, handwashing with soap and water, proper disposal of human waste, using clean cooking utensils and covering food to keep away flies were mentioned by 88.9%, 65.4%, 64.9%, and 63.4% of respondents, respectively. However, only 11% mentioned washing vegetables/fruits and 1.7% mentioned cholera vaccine as measures of cholera prevention.

Only 43% of the respondents were aware of ORS as a way of cholera treatment. Regarding facilities where a patient can be treated, most of the respondents did not know much about the designated cholera treatment centers and 93.7% said that they would go to clinics/hospitals to seek services at the onset of the disease. Only 3.7% of respondents went to traditional healers to seek treatment for cholera. About 81% of respondents mentioned that it took them less than 30 minutes to reach the health facility for cholera treatment while 17% of respondents spent 30–59 minutes reaching the health facility for treatment.

**Table 4** Distribution of households that received educational messages on cholera prevention

| Characteristics | Number of households | Percentage |
|-----------------|----------------------|------------|
| Hearing about prevention and treatment of cholera in the last 6 months prior to the survey | | |
| Yes | 339 | 96.9% |
| No | 11 | 3.1% |
| Don’t know | 2 | 0.57% |
| Source of information | | |
| Family member | 61 | 17.3% |
| Neighbor/friend | 83 | 23.58% |
| Clinician/healthcare worker | 124 | 36.6% |
| Radio | 45 | 13.3% |
| TV | 124 | 36.6% |
| Community meeting | 79 | 23.3% |
| Community health worker visiting home | 241 | 71.1% |
| Religious leader | 5 | 1.5% |
| Other | 27 | 8.0% |
| Receiving materials for education and prevention | | |
| Yes | 324 | 95.6% |
| No | 15 | 4.4% |
| Type of received materials for education and prevention | | |
| Chlorine solution | 44 | 13.6% |
| Soap | 305 | 94.1% |
| Oral rehydration solution | 63 | 19.4% |
| Purification tablets/aquatabs/diolavi | 165 | 50.9% |
| Verbal information | 238 | 73.5% |
| Print material (brochures, pamphlets) | 149 | 46.0% |
| Other | 5 | 1.5% |
| Don’t know | 1 | 0.3% |

**Practices relating to the prevention of cholera**

Table 6 presents practices relating to cholera preventive measures. Most of the respondents (62.5%) did not apply water treatment methods to make it safer to drink. About 78% of respondents believed that their water source was safe. Only 37% of respondents treated water by boiling, 35% used cloths to strain water, less than one-third of the households used a water filter (30%), and 24% used chlorine solution. Other households reported that PUR sachets, aqua-tabs, solar disinfection and other measures were used to treat water.

About 75% of respondents claimed washing their hands regularly, mainly before eating (91.5%), after eating (83.8%), and after using the toilet (75.3%). On the other hand, only 20% of respondents wash their hands after cleaning baby diapers.
DISCUSSION

Prevention of cholera in a high-risk population can be achieved through a comprehensive package in which health and hygiene education is an important component to encourage adaptation of behavior that promotes health (World Health Organization 2012). Few studies have explored the community’s cholera knowledge in the context of Yemen’s cholera outbreak. The present study assessed the knowledge and practice towards cholera among people in a high-epidemic governorate. In the present study, most community respondents were able to correctly identify symptoms and risk factors of cholera. This is comparable with a recent study on the knowledge, attitude and practices of communities in Aden that reported the awareness of 87% of respondents of the cholera symptoms. Similar to the study in Aden (Al-Sakkaf et al. 2020), our study found poor knowledge of transmission and prevention. It is worrisome that only 11% of the respondents in this study knew that proper washing of fruits and vegetables is an essential measure of cholera prevention. Inadequate washing of fruits and vegetables increases the risk of exposure to pathogens resulting in a huge prevalence of contagious diseases and water-borne outbreaks including cholera (Prüss-Üstün et al. 2008).

Table 5 | Distribution of households’ knowledge about cholera

| Characteristics                      | Number of households | Percentage |
|--------------------------------------|----------------------|------------|
| Symptoms associated with cholera     |                      |            |
| Fever                                | 38                   | 10.9%      |
| Vomiting                             | 326                  | 93.1%      |
| Watery diarrhea                      | 346                  | 98.9%      |
| Stomach/abdominal pain               | 76                   | 21.7%      |
| Bloody diarrhea                      | 3                    | 0.9%       |
| Dehydration                          | 98                   | 28.0%      |
| Other                                | 30                   | 8.6%       |
| Don’t know                           | 1                    | 0.3%       |
| Risk factors                         |                      |            |
| Eating contaminated food             | 241                  | 79.7%      |
| Drinking contaminated water          | 279                  | 86.9%      |
| Poor hygiene/not washing hands       | 220                  | 62.9%      |
| Flies/insects                        | 157                  | 44.9%      |
| Unwashed fruits/vegetables           | 157                  | 44.9%      |
| Other                                | 43                   | 12.5%      |
| Don’t know                           | 14                   | 4.0%       |
| Prevention methods                   |                      |            |
| Wash hands with soap and water       | 311                  | 88.9%      |
| Cook food thoroughly                 | 142                  | 40.6%      |
| Wash vegetables/fruit                | 41                   | 11.7%      |
| Dispose of human waste properly      | 229                  | 65.4%      |
| Boil water                           | 71                   | 20.3%      |
| Clean cooking utensils/vessels       | 227                  | 64.9%      |
| Treat water with chlorine products   | 58                   | 16.6%      |
| Cover food to keep away from flies   | 222                  | 63.4%      |
| Cholera vaccine                      | 6                    | 1.7%       |
| Cannot prevent                       | 3                    | 0.9%       |
| Other                                | 59                   | 16.9%      |
| Don’t know                           | 6                    | 1.7%       |
| Treatment of diarrhea                |                      |            |
| Go to a cholera treatment center     | 13                   | 3.7%       |
| Go to clinic/hospital                | 328                  | 93.7%      |
| Use oral rehydration solution        | 151                  | 43.1%      |
| Use a homemade sugar-salt solution   | 4                    | 1.1%       |
| Go to a traditional healer           | 13                   | 3.7%       |
| Home remedy                          | 2                    | 0.6%       |
| Do not treat                         | 12                   | 3.4%       |
| Other                                | 2                    | 0.6%       |
| Time taken to reach the health facilities for cholera treatment | | |
| <30 min                              | 269                  | 80.5%      |
| 30–59 min                            | 58                   | 17.4%      |
| 1–2 hours                            | 7                    | 2%         |
Evidence indicated that the risk of cholera was highly associated with open defecation (Cowman et al. 2017). Although a low percentage of the households reported that they practice open defecation, observation revealed evidence of open defecation near the home in about 23% of households. The data in this study reflect that most respondents have access to latrines, but still open defecation has been practiced in these communities. This is in agreement with a study from India, which indicated people practice open defecation even in areas with high latrine coverage (Barnard et al. 2013). Another study from four states in India identified over 80% of households that own latrines have at least one member practicing open defecation, necessitating a large-scale campaign to promote latrine use (Coffey et al. 2014). Qualitative research is necessary to understand the social and cultural factors associated with the practice of open defecation in Yemen to support the ongoing efforts of reducing the risk of cholera.

Oral rehydration solution is a widely known lifesaving therapy for the management of cholera (Victora et al. 2000). The perceived knowledge of the respondents about ORS was significantly low (43.1%). In contrast, higher levels of knowledge were reported from Haiti (90%), Bangladesh (92%), and Nigeria (89%) (de Rochars et al. 2011; Wahed et al. 2013; Ogbeyi et al. 2017). This might be due to the conducted education campaign not emphasizing the importance of ORS as a therapy for cholera management. Furthermore, our study found a lack of knowledge about the cholera vaccine similar to

Table 6 | Distribution of households that practice preventive measures against cholera

| Characteristics | Number of households | Percentage |
|-----------------|----------------------|------------|
| Doing anything to the water to make it safer to drink by households | Yes | 132 | 37.5% |
| | No | 220 | 62.5% |
| Used ways to make the water safer to drink by households (n = 132) | Boil the water | 49 | 37.1% |
| | Use water filter | 39 | 29.5% |
| | Strain using cloth | 46 | 34.8% |
| | Add PUR sachet | 14 | 10.6% |
| | Aqua-tabs | 12 | 9.1% |
| | Bleach/chlorine | 31 | 23.9% |
| | Let it stand/settle | 14 | 10.6% |
| | Solar disinfection | 7 | 5.3% |
| | Other | 3 | 2.3% |
| | Unknown | 1 | 0.8% |
| How many times do you treat water before using it (n = 132) | All the time | 75 | 56.8% |
| | Most of the time | 28 | 21.2% |
| | Sometimes | 26 | 19.7% |
| | No treatment in past 6 months | 3 | 2.3% |
| The last treatment of the water before drinking (n = 132) | Last 24 hours | 59 | 44.7% |
| | Between 24 and 48 hours | 26 | 19.7% |
| | More than 48 hours | 25 | 18.9% |
| | No treatment | 19 | 14.4% |
| | Unknown | 3 | 2.3% |
| Reasons for drinking water without treatment (n = 220) | The water source is safe | 171 | 77.7% |
| | No chlorine solution in the house | 20 | 9.1% |
| | No money/cannot afford | 31 | 14.1% |
| | Too busy | 8 | 3.6% |
| | Complained about the taste/smell | 22 | 10.0% |
| | Other | 20 | 9.1% |
| Wash hands of household’s caregivers (n = 352) | Yes | 265 | 75.3% |
| | Occasionally | 87 | 24.7% |
| When respondents wash their hands (n = 352) | After using the toilet | 265 | 75.3% |
| | Before eating | 322 | 91.5% |
| | After eating | 295 | 83.8% |
| | After cleaning tables | 102 | 29.0% |
| | After changing baby diapers | 70 | 19.9% |
| | After cleaning the home | 209 | 59.4% |
| | Other | 76 | 21.6% |
the finding of a recent study in Aden (Al-Sakkaf et al. 2020). It is essential to incorporate vaccine education into awareness campaigns to ensure public intake.

The present study shows that most respondents do not treat water mainly because they believe the water source is safe, which was also reported in the findings of the Aden study (Al-Sakkaf et al. 2020). However, microbiological testing of 11 untreated piped water sources of people who claimed safety of their water source in Haiti indicated that 7 were positive for fecal contamination (*Escherichia coli*) (de Rochars et al. 2011). Treating drinking water was an essential protective factor during the 2010 cholera epidemic (Connor et al. 2011), and it was associated with a significant reduction of cholera incidence in other countries (Conroy et al. 2001; Colwell et al. 2003).

Results of the present study revealed an important problem, which is the scarcity of water in about 30% of households. Insufficient water is highly linked to the heightened burden of diseases and it is a major obstacle to adopting regular handwashing with soap (Prüss-Ustün et al. 2014; Horng et al. 2016). The functionality of basic water and sanitation services has been severely affected by repeated damage to critical infrastructure since the start of the war. Additionally, water governance in the current situation is unable to provide sustainable and equitable use of water (WASH Cluster 2020).

The study found discrepancies related to preventive practices and education. For example, quite a high number of respondents received purification tablets (50%) compared with those who know it as a preventive measure of cholera (16.6%) and those who use it in the treatment of drinking water (8.8%). Based on the Aden study, Al-Sakkaf et al. (2020) argue for improving the design, content, and implementation of education campaigns considering the culture and background of the community. We do applaud this thought besides our belief that stakeholders must provide all the requirements to the communities enabling them to adopt good practices and to maintain both health and dignity. These include proper quantity and quality of water and improved sanitation system.

A high level of knowledge did not essentially translate into a high level of practice, a finding that is similar to other studies (Quick et al. 1996; de Rochars et al. 2011; Kennedy et al. 2017). Our study revealed that respondents who reported knowing the importance of handwashing as a preventive measure (88.9%) were greater than those who reported they wash their hands regularly 75.3%. Regarding handwashing after defecation, our findings are in contrast with findings of the Aden study and studies in other countries that found a high level of knowledge among respondents (Kennedy et al. 2017; Al-Sakkaf et al. 2020). Moreover, our study identified low knowledge about handwashing after changing baby diapers, indicating that there is a gap in knowledge about the critical times of hand washing and necessitating a comprehensive education campaign in the future.

The study was limited to Al-Mahweet governorate in Yemen, so it is not representative for all of Yemen. However, the findings of this study could be relevant to similar rural settings. The study design is vulnerable to response bias. The respondents’ knowledge may not represent their actual practices. To minimize this bias, we tried to validate survey findings with the information captured by direct observation during the administration of the interviews.

CONCLUSION
In conclusion, this study revealed a high knowledge about symptoms and risk factors of cholera and poor knowledge of disease transmission and prevention measures. Various gaps were obvious in different aspects of practices, such as water treatment and defecation practices. The study also demonstrated discrepancies between preventive practices and education. Cholera preventive plans should contain a comprehensive education campaign to improve knowledge and preventive practices. Stakeholders should support communities with sustainable water and sanitation systems as well as conducting more qualitative research to identify communities’ needs and perspectives, and thus design prevention programs accordingly.

DATA AVAILABILITY STATEMENT
Data cannot be made publicly available; readers should contact the corresponding author for details.

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