

Effect of a water, sanitation and hygiene program on handwashing with soap among household members of diarrhoea patients in healthcare facilities in Bangladesh: a cluster-randomised controlled trial of the CHoBI7 mobile health program

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Abstract

OBJECTIVE The Cholera-Hospital-Based-Intervention-for-7-days (CHoBI7) is a water treatment and handwashing with soap intervention for diarrhoea patients and their household members which is initially delivered in a healthcare facility setting. This study evaluated the effectiveness of CHoBI7 program delivery in increasing handwashing with soap in a healthcare facility setting among diarrhoea patients and their household members.

METHODS A randomised controlled trial of the CHoBI7 program was conducted among 404 diarrhoea patients and their accompanying household members in healthcare facilities in Dhaka, Bangladesh. The ‘Standard Message’ Arm received the standard message given in Bangladesh to diarrhoea patients on the use of oral rehydration solution. The ‘Health Facility Visit + Soapy Water’ Arm received the standard message, the CHoBI7 communication module delivered bedside to the patient; and a soapy water bottle in the healthcare facility. The ‘Health Facility Visit + Handwashing Station’ Arm received this same intervention plus a small plastic handwashing station. Within 24 h of intervention delivery, three-hour structured observation of handwashing practices at stool/vomit- and food-related events (key events) was conducted in healthcare facilities of diarrhoea patients and their accompanying household members.

RESULTS Compared to the Standard Message Arm, there was significantly more handwashing with soap at key events in both the Health Facility Visit + Soapy Water Arm (51% *vs.* 25 %) (Odds Ratio: 3.02; (95% Confidence Interval (CI): 1.41, 6.45) and the Health Facility Visit + Handwashing Station Arm (58% *vs.* 25%) (OR: 4.12; (95% CI: 1.86, 9.14).

CONCLUSION These findings demonstrate that delivery of the CHoBI7 communication module and provision of a soapy water bottle to diarrhoea patients and their accompanying household members presents a promising approach to increase handwashing with soap among this high risk population in a healthcare facility setting in Bangladesh.

keywords handwashing, structured observation, healthcare facilities, diarrhoeal disease, Bangladesh

Sustainable Development Goals (SDGs): SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 17 (partnerships for the goals)

Introduction

Diarrhoea is a leading cause of child mortality globally, causing 500 000 death annually [1–4]. In Bangladesh alone, there are estimated to be over 76 million diarrhoea

episodes each year, contributing to 814 082 disability-adjusted life years (DALYs) [4–6]. Furthermore, diarrhoeal diseases have been shown to contribute to impaired growth in susceptible paediatric populations [7]. Previous studies have identified lack of caregiver handwashing

with soap and water treatment, poor water storage practices and lack of caregiver awareness of diarrhoea prevention as risk factors for childhood diarrhoeal disease [8, 9]. Handwashing with soap and point-of-use chlorination of drinking water can significantly reduce diarrhoeal disease in children less than five years of age [10].

Healthcare-acquired infections are a major problem in healthcare facility settings in Bangladesh [11, 12]. Healthcare-acquired infections are a concern not only for patients and healthcare workers but also for the family members that care for patients in healthcare facilities [13]. These family members are often the caregivers responsible for cleaning the vomit and faeces of patients in healthcare facilities in low resource settings because of staff shortages and limited infrastructure in public healthcare facilities [11, 12, 14, 15]. Public hospitals in Bangladesh are often overcrowded and lack adequate handwashing infrastructure, sanitary facilities and infection control programs [11, 12, 16]. This creates an environment that puts family caregivers at an increased risk of healthcare-acquired infections [11, 14, 15].

Previous studies have found that household members of diarrhoea patients are at much higher risk of diarrhoeal diseases (>100 times higher for cholera) than the general population during the 7-day period after the diarrhoea patient in their household is admitted to the healthcare facility [17,18]. Our recent study found that 37% of hospitalised cholera cases had at least one household member that developed cholera during this period [17, 18]. Despite this risk, there is no standard of care for this high-risk population. Our recent observational study in a healthcare facility in Dhaka, Bangladesh found handwashing with soap to be only 4% at stool, vomit and food-related events among cholera patients and their accompanying household members [14]. Handwashing with soap interventions delivered in healthcare facility settings have the potential to reduce healthcare-acquired infections among caregivers of patients [19]. However, little is known on how to encourage individuals to maintain these behaviours over time, or effective delivery of water, sanitation and hygiene (WASH) interventions in healthcare facility settings [19, 20].

In an effort to reduce diarrhoeal diseases among household members of diarrhoea patients, our research group developed the Cholera Hospital-Based Intervention for 7 days (CHoBI7). CHoBI7 is a water treatment and handwashing with soap intervention that leverages the time patients and caregivers spend in healthcare facilities for WASH intervention delivery [1, 2]. The CHoBI7 program, delivered at the patient's bedside and during home visits, includes a pictorial module on diarrhoea transmission and prevention, a handwashing station (bucket with

lid, tap and plastic basin), soapy water bottle (water and detergent powder), drinking water vessel with lid and tap and chlorine tablets for water treatment. The randomised controlled trial (RCT) of CHoBI7 demonstrated that this intervention was effective in significantly reducing symptomatic cholera and led to sustained handwashing with soap and improved water quality 12 months post-intervention [2, 21].

In an effort to take the CHoBI7 program to scale across Bangladesh, we are currently partnering with the Bangladesh Ministry of Health and Family Welfare to develop and evaluate scalable approaches for program delivery. In line with this objective, we have redesigned the CHoBI7 program to remove the need for frequent home visits for intervention delivery by health promoters. In this study, we are investigating the effectiveness of this more scalable approach for CHoBI7 program delivery on handwashing with soap among diarrhoea patients and their accompanying household members in healthcare facility settings [22]. We hypothesised that delivery of the CHoBI7 pictorial communication module by a health promoter in the healthcare facility and provision of a soapy water bottle would increase handwashing with soap practices among household members of diarrhoea patients in the healthcare facility more than the standard message given in Bangladesh on oral rehydration solution (ORS) use. In addition, we hypothesised that delivery of this intervention with a handwashing station would increase handwashing with soap more than only the CHoBI7 pictorial communication module by a health promoter and provision of a soapy water bottle.

Methods

To evaluate the effectiveness of delivery of this intervention on handwashing with soap practices in a healthcare facility setting, we conducted an RCT of the CHoBI7 program among 404 diarrhoea patients and their accompanying household members (170 diarrhoea patients and 234 household members) in private and government healthcare facilities in Dhaka, Bangladesh from December 2016 to April 2018. Participants were randomised to one of three study arms by hospital ward and by the day of the week they were admitted to the healthcare facility. The 'Standard Message' Arm received the standard message in Bangladesh given to diarrhoea patients on the use of ORS. The 'Health Facility Visit + Soapy Water' Arm received: (1) the standard message; (2) the CHoBI7 pictorial communication module delivered by a health promoter bedside to the patient in the healthcare facility; and (3) a soapy water bottle (water and detergent powder in a 500 ml recycled plastic bottle) provided in the

healthcare facility. The 'Health Facility Visit + Handwashing Station' Arm received this same intervention plus a small plastic handwashing station which was filled with water by the patient's caregiver during the CHoBI7 module delivery in the healthcare facility. The cost of a bottle of soapy water is 0.07 USD (recycled water bottle and detergent powder) and the handwashing station (bucket with lid and tap, stool and basin) is 4.77 USD.

To be eligible for the trial, diarrhoea patients had to meet the following criteria: (1) have had 3 or more loose stools over the past 24 h; (2) plan to reside in Dhaka for the next 12 months; (3) have no basin for running water in their home (mostly slum areas of Dhaka); (4) have a child under five years of age in their household; and (5) have a working mobile phone in the household (eligibility for the CHoBI7 mobile health program delivered after discharge from the healthcare facility [22]). Household members of the diarrhoea patient were eligible for the trial if: (1) they shared the same cooking pot and resided in the same home with the diarrhoea patient for the last three days; and (2) planned to reside with the diarrhoea patient for the next 12 months. The study was nested within the larger RCT of the CHoBI7 mobile health program which followed diarrhoea patient households for 12 months to evaluate the effectiveness of the program on sustained WASH behaviours and reductions in diarrhoea and improvements in child growth [23]. A detailed description of the intervention is published elsewhere [22].

Within 24 h of enrolment, trained research assistants conducted three-hour structured observation of handwashing practices in healthcare facilities of diarrhoea patients and their accompany household members. Handwashing information was recorded during the following key events during healthcare facility structured observation: (1) after contact with faeces or vomit and (2) before food-related events (cutting fruit or salad or smashing foods, before eating and feeding). Only one diarrhoea patient and their accompanying household members were observed in a single structured observation. Blinding could not be performed for the research assistants because intervention hardware was present. The intervention and evaluation team were separate individuals. Households and patients were informed that structured observation was being conducted as a sub-study to evaluate patient and caregiver activities while in healthcare facilities for the treatment of diarrhoea, handwashing practices were not mentioned. Informed consent was obtained from all enrolled participants. Spot-checks were performed during structured observations to assess the presence of soap at bathroom handwashing areas used by patients and accompanying household members.

Statistical analysis

The percentage of diarrhoea patients and their accompanying household members handwashing with soap or water only at a key event was calculated by study arm. Logistic regression models were performed using generalised estimating equations to account for clustering within households and to approximate 95% confidence intervals (CI). Because 12 years of age and older is generally the age group where household members are attending to patients we focused our analysis on this age group. Those less than 12 years of age are included in the Supplementary Table 1. We calculated the time between patients' enrolment and the beginning of healthcare facility structured observation and the time of day for intervention delivery for all patient households and compared the differences between arms using ANOVA. The percentage of handwashing basins with soap present at bathroom handwashing areas was also calculated. These analyses were performed using STATA version 13 software (Stata Corp., College Station, TX, USA).

Ethical approval

The study protocol was approved by the Ethical Review Committee at icddr,b (PR-15133) and the Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health (6785).

Results

Four hundred and four diarrhoea patients and their accompanying household members were present for a healthcare facility structured observation visit (170 diarrhoea patients and 234 household members) (Table 1). Sixty-six percent (268) of participants were female and the median age was 19 years (range: 0.08–80 years) (Table 1). Twenty nine percent (50/170) of patient households had a concrete roof, 23% (39/170) had tin walls and 88% (149/170) of households had at least one household member that could read and write. Two hundred ninety nine participants had a key event during structured observation. There was no significant difference between study arms in the time from enrolment to structured observation ($P = 0.33$) or in the time of day for intervention delivery ($P = 0.25$). Soap was present at 91% (154/170) of handwashing areas at healthcare facilities during spot checks, and all healthcare facility handwashing stations had water.

Table 1 Participants' characteristics by study arm in healthcare facilities in Dhaka, Bangladesh, 2016–2018

	Standard Message Arm %(<i>n</i> / <i>N</i>)	Health Facility Visit + Handwashing Station Arm %(<i>n</i> / <i>N</i>)	Health Facility Visit + Soapy Water Arm %(<i>n</i> / <i>N</i>)
Index Diarrhoea Patients	43% (54/126)	41% (59/144)	43% (57/134)
Household Members of Index Diarrhoea Patients	57% (72/126)	59% (85/144)	57% (77/134)
Age			
Mean $\pm$ SD (Min–Max)	15.2 $\pm$ 13.8 [0.17–50]	16.6 $\pm$ 15.9 [0.83–80]	15.5 $\pm$ 14.5 [0.25–58]
0–5 Years	42% (53/126)	40% (57/144)	43% (57/134)
5–12 Years	4% (5/126)	5% (7/144)	3% (4/134)
12–18 Years	1% (1/126)	3% (4/144)	1% (2/134)
18 and above	53% (67/126)	53% (76/144)	53% (71/134)
Gender			
Female	63% (79/126)	68% (98/144)	68% (91/134)
Household level education			
At least one household member can read and write	85% (46/54)	85% (50/59)	93% (53/57)
Household roof type			
Tin	65% (35/54)	78% (46/59)	68% (39/57)
Concrete	35% (19/54)	22% (13/59)	32% (18/57)
Household wall type			
Concrete	76% (41/54)	68% (40/59)	75% (43/57)
Mud	4% (2/54)	3% (2/59)	4% (2/57)
Tin	19% (10/54)	29% (17/59)	21% (12/57)
Other	2% (1/54)	0% (0/59)	0% (0/57)

SD, standard deviation.

Household members of diarrhoea patients

There were 187 household members of diarrhoea patients that were 12 years of age or older with a key event during the structured observation period. Fifty eight percent (38/65) of the Health Facility Visit + Handwashing Station Arm participants, 51% (34/67) of the Health Facility Visit + Soapy Water Arm participants and 25% (14/55) of the Standard Message Arm participants washed both hands with soap at a key event (Table 2). During faeces- and vomit-related events, 57% (29/51) of participants in the Health Facility Visit + Handwashing Station Arm, 49% (26/53) of participants in the Health Facility Visit + Soapy Water Arm and 29% (12/41) of participants in the Standard Message Arm washed both hands with soap. For food-related events, 25% (16/63) of participants in the Health Facility Visit + Handwashing Station Arm, 19% (11/59) of participants in the Health Facility Visit + Soapy Water Arm, and 9% (5/53) of participants in the Standard Message Arm washed both hands with soap.

Thirty five percent (23/65) of the Health Facility Visit + Handwashing Station Arm participants, 42% (28/67) of the Health Facility Visit + Soapy Water Arm participants and 51% (28/55) of the Standard Message Arm

participants washed both hands with water only at a key event. During faeces- and vomit-related events, 14% (7/51) of participants in the Health Facility Visit + Handwashing Station Arm washed both hands with water only, 23% (12/53) of participants in the Health Facility Visit + Soapy Water Arm and 41% (17/41) of participants in the Standard Message Arm. For food-related events, 27% (17/63) of participants in the Health Facility Visit + Handwashing Station Arm washed both hands with water only, 32% (19/59) of participants in the Health Facility Visit + Soapy Water Arm and 34% (18/53) of participants in the Standard Message Arm.

Diarrhoea patients

There were 14 diarrhoea patients 12 years of age or older with a key event during the structured observation period. Three of five Health Facility Visit + Handwashing Station Arm participants, one of two Health Facility Visit + Soapy Water Arm participants and five of seven Standard Message Arm participants washed both hands with soap at a key event. During faeces-related events, three of five Health Facility Visit + Handwashing Station Arm participants, the one Health Facility Visit + Soapy Water Arm participant and four of six Standard Message

Table 2 Percentage of household members of diarrhoea patients washing hands with soap during healthcare facility structured observation.

Event	Percentage of household members of diarrhoea patients washing both hands with soap in the healthcare facility			Odds ratio (OR) compared to Standard Message Arm	
	Standard Message Arm % (n/N)	Health Facility Visit + Handwashing Station Arm % (n/N)	Health Facility Visit + Soapy Water Arm % (n/N)	Health Facility Visit + Handwashing Station Arm OR (95% CI)	Health Facility Visit + Soapy Water Arm OR (95% CI)
All Events	25 (14/55)	58 (38/65)	51 (34/67)	4.12 (1.86, 9.14)	3.02 (1.41, 6.45)
Faeces and Vomit	29 (12/41)	57 (29/51)	49 (26/53)	3.19 (1.31, 7.75)	2.33 (0.97, 5.60)
Food	9 (5/53)	25 (16/63)	19 (11/59)	3.27 (1.11, 9.64)	2.20 (0.71, 6.82)

Arm participants washed both hands with soap. For food-related events, two of four Health Facility Visit + Handwashing Station Arm participants, one of two Health Facility Visit + Soapy Water Arm participants and one of five Standard Message participants washed both hands with soap. One out of seven Standard Message Arm participants, none of the five Health Facility Visit + Handwashing Station Arm participants, and one of the two Health Facility Visit + Soapy Water Arm participants washed their hands with water only at a key event. During faeces- and vomit-related events, none of the participants washed their hands with water only. For food-related events, one of two Health Facility Visit + Soapy Water Arm participants, one of five Standard Message arm participants, and none of the Health Facility Visit + Handwashing Station Arm participants washed their hands with water only.

Regression Analyses

Household members of diarrhoea patients in the Health Facility Visit + Handwashing Station Arm washed their hands with soap at a key event significantly more often than households members in the Standard Message Arm (58% *vs.* 25%) (Odds ratio (OR): 4.12; (95% confidence interval (CI): 1.86, 9.14). There was also a significant increase in handwashing with soap at a key event in the Health Facility Visit + Soapy Water Arm compared to the Standard Message Arm (51% *vs.* 25 %) (OR: 3.02; (95% CI: 1.41, 6.45). There was no significant difference in handwashing with soap at a key event between the Health Facility Visit + Handwashing Station Arm compared to the Health Facility Visit + Soapy Water Arm (58% *vs.* 51%) (OR: 0.73; (95% CI: 0.37, 1.46). Household members of diarrhoea patients in the Health Facility Visit + Handwashing Station Arm washed their hands with soap at faeces- and vomit-related events significantly more often than household members in the Standard

Message Arm (57% *vs.* 29%) (Odds ratio (OR): 3.19; (95% confidence interval (CI): 1.31, 7.75). There was also a significant increase in handwashing with soap at a food event in the Health Facility Visit + Handwashing Station Arm compared to the Standard Message Arm (25% *vs.* 9%) (OR: 3.27; (95% CI: 1.11, 9.64).

Discussion

Household members of diarrhoea patients in both CHoBI7 program arms had more than three times the odds of handwashing with soap at a key event in a healthcare facility setting compared to those in the Standard Message Arm. These findings demonstrate the effectiveness of the CHoBI7 program in increasing handwashing with soap among this high-risk population in a healthcare facility setting. Furthermore, this program was highly effective even with only the provision of a soapy water bottle to facilitate handwashing with soap which represents a much more scalable low cost approach for program delivery compared to provision of a plastic handwashing station to all diarrhoea patients. Given the high rates of healthcare-acquired infections globally and the high risk of diarrhoeal diseases among household members of diarrhoea patients, there is an urgent need for interventions such as the CHoBI7 program to increase handwashing with soap among family members caring for diarrhoea patients in healthcare facilities.

We attribute the success of the CHoBI7 program in increasing handwashing with soap behaviours among caregivers of diarrhoea patients in a healthcare facility setting to the theory-driven evidence-based approach for intervention development. Biomedical models of behaviour change emphasise health information-based messages focused on prevention and treatment of diseases [24, 25]. This approach does not take into consideration the importance of contextual, psychosocial and technological factors that serve as facilitators and barriers to performing the promoted behaviours. The development

of the CHoBI7 program was informed by the Integrated Behavioural Model for Water, Sanitation and Hygiene, and focused on targeting the multi-level multi-dimensional factors influencing handwashing with soap behaviours in both a healthcare facility and household setting. Intervention development included 60 semi-structured interviews, intervention planning workshops and a pilot study of 52 households [26]. The handwashing station was introduced in the healthcare facility to increase self-efficacy and convenience by providing a place to wash hands with soap bedside to patients. The handwashing station and soapy water bottle also likely served as important cues to action for handwashing with soap among caregivers of diarrhoea patients [27, 28]. A study in Bangladesh found that a convenient handwashing place and the availability of water significantly increased the percentage of handwashing with soap events [29]. Previous studies have also found that handwashing behaviour is associated with the availability of cleaning agents like water and soap [30, 31]; therefore, the soapy water provided was likely also an important facilitator of handwashing with soap behaviour. Theory-driven evidence-based interventions are needed to increase handwashing with soap among caregivers of patients in healthcare facility settings globally.

The CHoBI7 program accompanied by provision of a bottle of soapy water is a low-cost approach to not only increase handwashing with soap in a healthcare facility setting among caregivers, but to also increase these practices when the patients and their accompanying household members return home. Our RCT of this CHoBI7 program accompanied by weekly voice and text messages promoting handwashing with soap and water treatment significantly increased handwashing with soap at stool- and food-related events and improved stored drinking water quality 12 months after program enrolment, even in households that only had a single in-person visit in a healthcare facility for intervention delivery [23]. Despite the high rates of healthcare-acquired infections among patients and their family caregivers, there are few interventions targeting this high-risk population in a healthcare facility setting. Most of the WASH programs in Bangladesh are community-based interventions. Therefore, innovative approaches such as the CHoBI7 program are needed to facilitate handwashing with soap behaviours in healthcare facility and household settings.

Very few caregivers washed their hands with soap at food-related events (9%) in healthcare facilities in the Standard Message Arm of the trial. Although this was higher for faeces and vomit related events at 29% in the Standard Message Arm, most caregivers still did not wash their hands with soap at these important key events in a high-

risk healthcare facility setting. Previous studies in Bangladesh found that caregiver handwashing with soap at food- and stool-related events in hospitals was rare (3–6%) [14, 16]. The Bangladesh National Hygiene Baseline Survey found that 3% of caregivers washed both hands with soap in a healthcare facility settings at faeces- and food-related events [16]. These findings likely reflect the challenges caregivers face accessing handwashing stations that are often far from the bedside of patients. Our formative work for intervention development found that caregivers of children with diarrhoea admitted to healthcare facilities were often fearful that their child would fall off the side of the bed if they went to the healthcare facility's handwashing station [26]. Handwashing with soap events were also often missed because patients needed care at the same time. In addition, often handwashing stations were far from the beds of diarrhoea patients which made them difficult for caregivers to access, and some wards had handwashing stations that were not functional for caregivers to use.

Our previous study in Bangladesh, found that delivery of the CHoBI7 program in the household increased the odds of handwashing with soap at home by 14 times during the one week high risk period after the diarrhoea patient presented in the healthcare facility, compared to only a three to four times higher odds in the present study in a healthcare facility setting [1, 2]. This difference likely reflects again the challenges of handwashing with soap in a healthcare facility setting. Handwashing during food preparation in our healthcare facility setting is rarely done because family caregivers of patients often lack support with feeding and cleaning ill patients and their soiled beds [26]. In settings where handwashing stations with running water and soap are unavailable, use of hand sanitiser could be one alternative for cleaning hands, as it is effective in killing viruses and bacteria and has the added advantage of not requiring water [32]. The diarrhoea patient households would need to be trained on the proper use of this cleansing agent. Innovative approaches are needed to increase handwashing with soap behaviour in healthcare facility settings among the family caregivers of patients to reduce their exposure to infectious agents.

This study had some limitations. First, we only focused on diarrhoea patients and their accompanying household members, and therefore cannot generalise these handwashing findings to other patient populations. Second, we did not measure hand contamination, and therefore cannot conclude how the increased rates of handwashing with soap influenced rates of hand contamination. Future healthcare facility-based studies should also collect hand rinse samples. Third, we conducted this study in urban healthcare facilities, and therefore cannot generalise these findings to rural settings.

This study also had several strengths. First is the randomised controlled trial study design. Second is the inclusion of the two intervention arms, one that received soapy water and the CHoBI7 module, and one that received this same intervention and a handwashing station in the healthcare facility which allowed us to investigate the added benefit of the handwashing station. Third is the use of structured observation for program evaluation. Fourth is the theory-driven evidence-based approach for intervention development.

Despite the risk of healthcare-acquired infections among patients and family caregivers in a healthcare facility setting, there are few intervention programs to train and protect this high-risk group globally. The CHoBI7 program has the potential to facilitate handwashing with soap behaviour change among this high-risk population. Our partners at the Bangladesh Ministry of Health and Family Welfare recommend the CHoBI7 program be delivered in the oral rehydration corner of government healthcare facilities across Bangladesh, and that diarrhoea patients be provided a single 500 ml soapy water bottle and a 1-week supply of chlorine tablets [26]. Demonstration stations in Oral Rehydration Therapy corners, present in all government health facilities in Bangladesh, displaying the handwashing station and water vessel promoted in the CHoBI7 program were also recommended. Since almost all materials needed to make these items are already available in most households in Bangladesh (e.g. bucket, stool and basin), patients and their family members can be trained in the healthcare facility by health promoters on how to prepare these items in their home. In our recent trial, we observed households neighbouring enrolled diarrhoea patient households that had made their own handwashing stations, soapy water bottles and water vessels based on the CHoBI7 design using items found in their home.

Conclusion

The CHoBI7 program increased handwashing with soap among caregivers of diarrhoea patients in a healthcare facility setting. We are currently partnering with the Bangladesh Ministry of Health and Family Welfare to develop a scaling plan to deliver the CHoBI7 program across Bangladesh. Our findings suggest that CHoBI7 is a promising approach to facilitate handwashing with soap in healthcare facilities among the family caregivers of patients.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Supplementary Table 1. Handwashing practices among diarrhea patients and household members during health-care facility structured observation for individuals less than 12 years of age.

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