

Psychosocial Factors Mediating the Effect of the CHoBI7 Intervention on Handwashing With Soap: A Randomized Controlled Trial

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Abstract

Inadequate hand hygiene is estimated to result in nearly 300,000 deaths annually, with the majority of deaths being among children younger than 5 years. In an effort to promote handwashing with soap and water treatment behaviors among highly susceptible household members of cholera patients, we recently developed the Cholera-Hospital-Based Intervention-for-7-Days (CHoBI7); *chobi* means picture in Bengali. This 1-week handwashing with soap and water treatment intervention is delivered by a promoter in the hospital and the home to cholera patients and their household members. In our randomized controlled trial of this intervention, we observed a significant reduction in symptomatic cholera infections during the 1-week intervention period compared to the control arm and sustained high uptake of observed handwashing with soap behaviors up to 12 months postintervention. The aim of the present study was to assess the underlying mechanism of change that led to the high handwashing with soap behavior observed among participants who received the CHoBI7 intervention. Handwashing with soap was measured using 5-hour structured observation, and psychosocial factors were assessed using a structured questionnaire among 170 intervention and 174 control household members enrolled in the CHoBI7 trial. To investigate potential mediators of the CHoBI7 intervention effect, mediation models were performed. Response efficacy was found to mediate the intervention's effect on habit formation for handwashing with soap at the 1-week follow-up, and disgust, convenience, and cholera awareness were mediators of habit maintenance at the 6- to 12-month follow-up. These results support the use of theory-driven approaches for the development and implementation of handwashing with soap interventions.

Keywords

Bangladesh, behavioral interventions, behavioral theories, diarrhea disease, handwashing with soap, mediation analysis, randomized controlled trial

Pneumonia and diarrhea are the leading causes of death in children under 5 years of age globally (Liu et al., 2012; Pruss-Ustun et al., 2014). Despite the extensive literature demonstrating that handwashing with soap substantially reduces this disease burden, only 19% of the world population is estimated to wash their hands with soap after coming into contact with human excreta (Fewtrell et al., 2005;

Freeman et al., 2014; Pruss-Ustun et al., 2014). Handwashing with soap promotion programs in low-income countries typically focus solely on educational messages related to diarrhea prevention and are often one-off in scope (Curtis et al., 2011). This is in spite of the literature demonstrating that a knowledge-focused approach to delivering water, sanitation, and hygiene (WASH) interventions may not be sufficient to

lead to sustained adoption of promoted behaviors or reductions in pediatric diarrhea over time (Hoque, Juncker, Sack, Ali, & Aziz, 1996; Lindquist et al., 2014; Luby et al., 2009).

Beyond assessing the efficacy of handwashing with soap interventions, it is important to understand their underlying mechanism of change (Michie & Abraham, 2004). This allows for a better understanding of why an intervention was effective or ineffective, and for future interventions to target identified behavioral determinants of handwashing with soap (Lippke & Ziegelmann, 2008; Michie & Abraham, 2004). However, there is only one handwashing with soap intervention study, to our knowledge, in a low-income country that has conducted a mediation analysis of measured psychosocial factors to understand this underlying mechanism of change (Contzen & Inauen, 2015). This study, conducted in rural Ethiopia, found descriptive norms, forgetting, and commitment strength to be mediators of the handwashing with soap intervention effect (Contzen & Inauen, 2015).

Rationale for Study

Severe cholera without adequate rehydration kills up to half of affected individuals (Sack, Sack, Nair, & Siddique, 2004). Household members of cholera cases are at more than a 100 times at risk of a cholera infection than the general population (Hughes et al., 1982; Spira, Khan, Saeed, & Sattar, 1980; Weil et al., 2009). This is likely because of secondary transmission from infected household members due to poor hygiene practices and shared contaminated environmental sources (Spira et al., 1980). The current standard of care for cholera patients at hospital discharge in Bangladesh is to provide oral rehydration solution (ORS) packets. There is no standard of care for the household members of cholera cases despite their very high risk of developing a cholera infection.

In an effort to develop a low-cost standard of care for the household members of cholera patients, we recently developed a hospital-based handwashing with soap and water treatment intervention titled Cholera-Hospital-Based-Intervention-for-7-days (CHoBI7) at the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Hospital in Dhaka, Bangladesh. In our randomized controlled trial (RCT) of this intervention, where CHoBI7 was compared with the standard message given in Bangladesh to diarrhea patients at discharge on ORS use, we observed a significant reduction in symptomatic cholera infections and a 47% reduction in the incidence of overall infections (George,

Monira, et al., 2016). Furthermore, we observed a 14 times higher odds of handwashing with soap in the intervention versus the control arm during the 1-week intervention period, and a 4 times higher odds 6 to 12 months postintervention (George, Jung, et al., 2016; George, Monira, et al., 2016). These findings demonstrated that the CHoBI7 intervention was highly effective at increasing handwashing with soap behaviors and conferred a significant health benefit.

In this present evaluation, we are building on this previous work by identifying why the CHoBI7 intervention was more effective than the standard message on ORS in increasing handwashing with soap behaviors. The first objective of this analysis is to investigate the impact of the CHoBI7 intervention on targeted psychosocial factors at 1 week and 6 to 12 months postintervention. The second objective is to conduct a mediation analysis to determine the underlying mechanism of change associated with the high efficacy of the CHoBI7 intervention on handwashing with soap behavior. Through this analysis we will be able to investigate the psychosocial factors related to handwashing with soap habit formation (1 week follow-up) and habit maintenance (6 to 12 months).

Method

Clusters and Participants

All study participants provided informed consent; consent was composed of adult participants (>18 years of age) signing an informed consent and/or parental consent form and children 12 to 17 years of age signing an assent form. All study procedures were approved by the research Ethical Review Committee of icddr,b and the Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health. This cluster RCT was conducted in Dhaka, Bangladesh, at Dhaka icddr,b hospital from June 2013 to January 2015 (Figure 1). A cluster was a cholera patient and their corresponding household members. A detailed description of the study design and power calculation is published elsewhere (George, Monira, et al., 2016).

Intervention

The CHoBI7 intervention includes the following: (1) a pictorial (*chobi* in Bengali) module delivered by a promoter using a flipbook on how cholera can spread through the environment,

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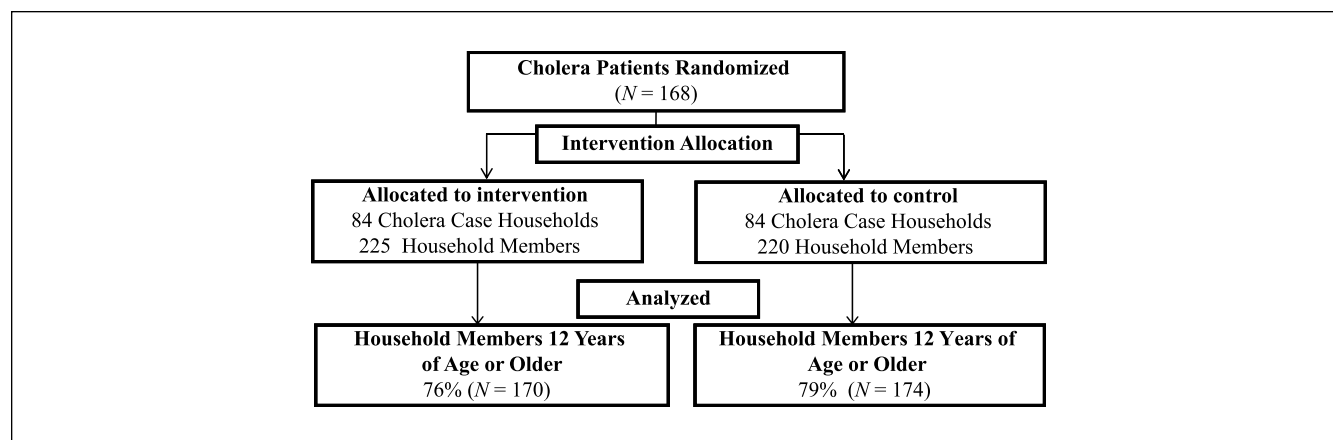


Figure 1. Flowchart of study participation.



Figure 2. Photos of flipbook on cholera transmission and handwashing with soap and water treatment.

how people can spread cholera to each other through contaminating food and water in their home, and instructions on proper handwashing with soap and water treatment practices (Figure 2) and (2) a cholera prevention package containing the following items was also given to households: a 3-month supply of chlorine tablets (Aquatabs sodium dichloroisocyanurate; Medentech, Wexford, Ireland, UK) for water treatment, a 1-week supply of soapy water bottles (made using detergent power and water), a handwashing station (bucket with lid and tap and basin), a sealed water vessel with cover to ensure safe water storage, and a poster with the recommended key times

to wash hands with soap and instructions on how to treat household drinking water using chlorine tablets (Figure 3). The recommended key times for handwashing with soap were (1) after using the toilet, (2) after cleaning a child's anus, (3) before eating, and (4) before preparing food. A trained health promoter at Dhaka icddr,b Hospital delivered this pictorial module and cholera prevention package to cholera patients and their accompanying family members during a consultation session in the hospital. These messages were then reinforced through household visits by the health promoter for the 1-week intervention period.



Figure 3. Intervention hardware: Handwashing station, bottle of soapy water, water vessel with cover, and chlorine tablets.

Study Enrollment

Randomization was conducted based on the day the cholera patient was admitted to the hospital. The control arm received the standard message given at health facilities in Bangladesh on the use of ORS for the treatment of diarrhea; the intervention arm received this standard message and the CHoBI7 intervention.

Measurement of Handwashing With Soap

Five-hour structured observation was conducted at 1 week and 6 to 12 months after baseline enrollment to assess handwashing practices. Data were collected using netbook computers. Handwashing practices were recorded at the following recommended key times promoted in the CHoBI7 intervention: (1) after using the toilet, (2) after cleaning a child's anus, (3) before eating, and (4) before preparing food. Households were informed that the structured observation visit was being conducted to evaluate day-to-day household activities in an urban setting in Bangladesh. We did not mention to participants that our objective was to observe handwashing practices. Information was also collected on household events unrelated to handwashing practices (e.g., child play behaviors) to prevent interviewers from entering data only at key times for handwashing, which could have revealed the purpose of our visit. In addition, there were separate teams for the intervention, interviewing, and structured observation activities.

Psychosocial Factors

Participants 12 years of age or older were administered a structured questionnaire at baseline and at 1 week and 6 to 12 months after enrollment. Items used for psychosocial factors were derived from the theory of planned behavior, the health belief model, the RANAS (Risks, Attitudes,

Norms, Abilities, and Self-regulation) model, and previous studies (Ajzen, 1985; Aunger et al., 2010; Carpenter, 2010; Dreifelbis et al., 2013; Mosler, Blöchliger, & Inauen, 2010). Because of time constraints during household interviews, most factors were limited to a single item. Given that no factor measured had more than three items, all items for each factor were evaluated individually. These questions were prepared in English, then translated into Bengali and pretested among 30 participants. Factors were ordinal and ranged from 1 to 5, except for cholera awareness, which had a score range of 0 to 10. Definitions and statements for each factor are included in Table 1. There were five new items added at the 6- to 12-month follow-up, and one perceived susceptibility item was removed at the 6- to 12-month follow-up because of its very high correlation (.91) with the other perceived susceptibility item used to measure this factor at the baseline and 1-week follow-up. The Behavior Change Technique used to target each psychosocial factor is described in Table 1.

Statistical Analysis

To compare baseline characteristics by study arm, we conducted a chi-square test for categorical variables, and a 2-sample *t* test for continuous variables. Pearson correlations were calculated for psychosocial factors. To compare psychosocial factors by study arm (see Hypotheses 1-8, Table 1), linear regression models were performed using generalized estimating equations, to account for clustering within households, with psychosocial items as the outcome and study arm as the predictor. To investigate potential mediators of the CHoBI7 intervention effect, simple mediation models were performed using the "INDIRECT" macro (Preacher & Hayes, 2008). Because directional hypotheses were tested for the mediation analysis, 90% confidence intervals were estimated. Bootstrapping with

Table 1. Psychosocial Factors Measured in CHoBI7 Randomized Controlled Trial.

Factor category ^a	Definition	Behavior change technique delivered	Hypothesized change with intervention	Statement
Remembering	To perform a behavior, it has to be remembered at the right time/situation (Tobias, 2009)	Poster on key times for handwashing with soap next to handwashing station	Hypothesis 1: Higher remembering	It is hard to remember to wash your hands with soap after using the toilet. It is hard to remember to wash your hands with soap before preparing a meal. Seeing soap after using the toilet makes you wash your hands.
Perceived Susceptibility ^b	A person's perception of his/her risk of contracting cholera (Orbell et al. 2009)	Pictorial module delivered by a promoter stating, "Because someone in your family has cholera you are at a very high risk of developing cholera for the next 7 days"	Hypothesis 2: Lower perceived susceptibility ^b	When your family member with cholera returned home from the hospital, how high or low were the chances that you would contract cholera? When your family member with cholera returned home from the hospital, how high or low were the chances that <i>your other family members</i> would contract cholera?
Cholera Awareness	An awareness of cholera transmission and prevention	Pictorial module delivered by a promoter on cholera transmission and prevention	Hypothesis 3: Higher cholera awareness	Quiz score (0-10 points) based on the following questions: Can you name three important ways cholera can be prevented? Can you please name the four key times for handwashing with soap? Can you name three important ways cholera is spread?
Dirt Reactivity	Only washing hands with soap in response to dirt, feces, or smell	Pictorial module delivered by a promoter stating, "Cholera has no taste or smell it's invisible therefore visibly clean hands can have cholera"	Hypothesis 4: Lower dirt reactivity	You wash your hands with soap only when they have a bad smell.
Disgust	Revulsion that is occasioned by the sight of excreta, rotten food, slime, and bugs (Curtis et al. 2001)	Pictorial module delivered by a promoter stating, (1) A most upsetting fact about cholera is that it often comes from human feces and (2) Cholera may spread from hands contaminated with feces; therefore when we prepare food or eat food without washing our hands with soap we could be eating feces that has cholera	Hypothesis 5: Higher disgust	You feel your hands are disgusting after cleaning up a child's feces.

(continued)

Table 1. (continued)

Factor category ^a	Definition	Behavior change technique delivered	Hypothesized change with intervention	Statement
Response Efficacy ^b	Judgments about the efficacy of a preventive response that will avert the perceived threat (Prentice-Dunn & Rogers, 1986)	Pictorial module delivered by a promoter stating, "To prevent getting cholera and giving cholera to the ones you love you should wash your hands with soap at the key moments specified"	Hypothesis 6: Higher response efficacy ^b	If you always wash your hands with soap what are the chances you will develop cholera?
Convenience (Instrumental Attitudes)	Beliefs about the benefits and costs of a behavior (Fishbein & Ajzen, 2010)	Enabling technology: Distribution of handwashing station and soapy water bottle by a promoter to facilitate handwashing with soap behaviors	Hypothesis 7: Higher convenience	It is inconvenient to always wash hands with soap. You have no time to wash your hands with soap.
Self-Efficacy ^c	The belief in one's capabilities to organize and execute the courses of action required to manage prospective situations (Bandura et al., 1997)	Enabling technology: Distribution of handwashing station and soapy water bottle by a promoter to facilitate handwashing with soap behaviors	Hypothesis 8: Higher self efficacy ^c	How sure are you that you can make soap for handwashing available for your family every day? How sure are you that you can always wash your hands with soap before eating? If someone in your home gets cholera, how sure are you that you can prevent the spread of cholera?

^aFactors are ordinal and range between 1 and 5, except for Cholera Awareness, which has a score range of 0 to 10, based on responses to open-ended questions. Answering options were as follows unless otherwise noted: 1 = strongly disagree, 2 = slightly disagree, 3 = neither agree nor disagree, 4 = slightly agree, and 5 = strongly agree. ^bThe answering options were the following: 1 = very low, 2 = low, 3 = neither low nor high, 4 = high, and 5 = very high. ^cThe answering options were as follows: 1 = not sure at all, 2 = not sure, 3 = neither sure nor not sure, 4 = a little sure, 5 = very sure.

10,000 resamples were performed. Handwashing with soap was defined as a handwashing with soap event at a recommended key time during the structured observation period. The *a* path was the effect of the intervention on the mediators (psychosocial factors), and the *b* path was the effect of the mediators on handwashing with soap at a recommended key time (Baron & Kenny, 1986).

Results

The 344 household members (170 intervention and 174 control) enrolled in the CHoBI7 trial were 12 years of age or older and were administered the psychosocial factor questionnaire at baseline and the 1-week follow-up. There were no significant differences in age ($p = .80$) or gender ($p = .79$) by study arm for household members that received the psychosocial factor questionnaire. The mean age for these participants was 31.5 years ($SD = 12.6$, range 12-75), and 65% were female. One hundred and thirty-five households had been enrolled at least 6 months prior when the 6- to 12-month follow-up survey was conducted, and 76% (103/135) of these eligible households were enrolled. There were a total of 159 enrolled participants (72 intervention and 87 control) in these household that were 12 years of age or older.

Fifty-six percent of these household members (75/186) washed their hands with soap at a key time during the 5-hour structured observation period at the 1-week follow-up (94% in the intervention arm vs. 19% in the control arm, $p < 0.0001$), and 38% (48/125) at the 6- to 12-month follow-up (56% in the intervention arm vs. 21% in the control arm, $p < .0001$).

The largest Pearson correlation coefficients for psychosocial items measured at baseline were for the two perceived susceptibility items (.91, $p < .0001$), the two remembering items (.66, $p < .0001$), and for the two convenience items (.44, $p < .0001$; Supplementary Tables 1 and 2, available online with this article at heb.sagepub.com). There were no significant differences in psychosocial items measured at baseline by study arm (Supplementary Table 3, available online with this article at heb.sagepub.com). At the 1-week follow-up there was significantly less difficulty remembering to wash hands with soap (remembering) in the intervention arm compared to the control arm for both items measured, consistent with Hypothesis 1 in Table 1 (Table 2). The intervention arm also had significantly higher cholera awareness and perceived response efficacy of handwashing with soap, consistent with Hypotheses 3 and 6. In addition, handwashing with soap was perceived to be significantly less inconvenient (convenience) in the intervention arm, consistent with Hypothesis 7.

At the 6- to 12-month follow-up, the intervention arm again had significantly less difficulty remembering (remembering) to wash hands with soap before preparing a meal, consistent with Hypothesis 1. Cholera awareness was also

significantly higher in the intervention arm compared to the control arm, consistent with Hypothesis 3. Dirt reactivity was significantly lower in the intervention arm while disgust was significantly higher, consistent with Hypotheses 5 and 6. In addition, in the intervention arm inconvenience (convenience) was again significantly lower and self-efficacy was significantly higher for all items measured, consistent with Hypotheses 7 and 8.

In the mediation models, response efficacy was found to significantly mediate the intervention effect at the 1-week follow-up (Table 3), while at the 6- to 12-month follow-up cholera awareness, disgust, and convenience were found to significantly mediate the intervention effect (Table 4).

Discussion

To our knowledge, this is the first study to investigate the underlying mechanism of change of a handwashing with soap intervention delivered in a low-income country using an RCT design. The CHoBI7 intervention significantly increased remembering, cholera awareness, disgust, response efficacy, convenience, and self-efficacy and significantly lowered dirt reactivity when compared to control households. These findings were consistent with Hypotheses 1, 3, 4, 5, 6, 7, and 8. Furthermore, we found that response efficacy mediated CHoBI7's effect on handwashing with soap habit formation at the 1-week follow-up, and disgust, convenience, and cholera awareness were mediators of habit maintenance at the 6- to 12-month follow-up. Through this study we were able to identify the psychosocial factors that mediated the high efficacy of the CHoBI7 intervention and to identify factors that should be targeted in future interventions.

Response efficacy was found to be significantly higher in the intervention arm and mediate the effect of the CHoBI7 intervention at the 1-week follow-up. This finding suggests that perceived efficacy of the promoted handwashing with soap behavior was a key motivator for habit formation. The behavior change technique used to target response efficacy was a pictorial module delivered by a promoter stating, "To prevent getting cholera and giving cholera to the ones you love you should treat all your drinking water with chlorine and wash your hands with soap at the key moments specified." This is the first study to our knowledge to find this association. Future studies should further investigate the role of response efficacy in handwashing with soap habit formation and maintenance.

Disgust was found to mediate the effect of the CHoBI7 intervention at the 6- to 12-month follow-up. This finding suggests that disgust plays an important role in maintenance of handwashing with soap behaviors. The behavior change technique we selected to target disgust was a pictorial module delivered by a promoter stating, "Cholera may spread from hands contaminated with feces therefore when we prepare food or eat food without washing our hands

Table 2. Analysis of Psychosocial Factors by Study Arm at Baseline, 1 Week, and 6 to 12 Months for All Participants.

Factor category ^a	Statement	1-Week follow-up (N = 344)			6- to 12-Month follow-up (N = 159)		
		Control, M (SD)	Intervention, M (SD)	p	Control, M (SD)	Intervention, M (SD)	p
Remembering	It is hard to remember to wash your hands with soap after using the toilet.	1.92 (1.57)	1.32 (1.04)	0.0001	1.86 (1.52)	1.46 (1.21)	.10
	It is hard to remember to wash your hands with soap before preparing a meal.	2.26 (1.69)	1.47 (1.17)	<.0001	2.99 (1.75)	2.31 (1.66)	.02
	Seeing soap after using the toilet makes you wash your hands.	—	—	—	4.86 (0.51)	4.86 (0.54)	.98
Perceived Susceptibility ^b	When your family member with cholera returned home from the hospital, how high or low were the chances that <i>you</i> would contract cholera?	3.58 (1.54)	3.66 (1.66)	0.63	1.98 (0.93)	1.73 (1.11)	.11
	When your family member with cholera returned home from the hospital, how high or low were the chances that <i>your other family members</i> would contract cholera?	3.27 (1.58)	3.10 (1.73)	0.42	—	—	—
Cholera Awareness	Quiz score (0-10 points) based on the following questions: Can you name three important ways cholera can be prevented? Can you please name the four key times for handwashing with soap? Can you name three important ways cholera is spread?	4.29 (1.69)	6.29 (1.70)	<.0001	4.26 (1.62)	5.57 (1.74)	<.0001
Dirt Reactivity	You wash your hands with soap only when they have a bad smell.	3.32 (1.88)	2.95 (1.96)	0.05	2.71 (1.84)	1.75 (1.35)	.001
Disgust	You feel your hands are disgusting after cleaning up a child's feces.	4.42 (1.14)	4.57 (1.06)	0.24	4.25 (1.21)	4.76 (0.63)	.01
Response Efficacy ^b	If you always wash your hands with soap what are the chances you will develop cholera?	1.31 (0.58)	1.09 (0.29)	<.0001	1.41 (0.79)	1.20 (0.65)	.07
Convenience	You have no time to wash your hands with soap.	1.59 (1.26)	1.23 (0.87)	0.003	1.85 (1.49)	1.39 (1.08)	.02
	It is inconvenient to always wash hands with soap.	—	—	—	1.77 (1.39)	1.28 (0.90)	.01
Self Efficacy ^c	If someone in your home gets cholera, how sure are you that you can prevent the spread of cholera?	—	—	—	4.38 (1.10)	4.86 (0.35)	.001
	How sure are you that you can make handwashing with soap available for your family every day?	—	—	—	4.81 (0.39)	5.00 (0.00)	.0009
	How sure are you that you can always wash your hands with soap before eating?	—	—	—	4.34 (1.10)	4.73 (0.79)	.01

Note. p value calculated using generalized estimating equations with the psychosocial factor as the outcome and study arm as the predictor (boldface indicates significant associations). M = mean; SD = standard deviation.

^aFactors are ordinal and range between 1 and 5, except for Cholera Awareness, which has a score range of 0 to 10, based on responses to open-ended questions. Answering options were as follows unless otherwise noted: 1 = *strongly disagree*, 2 = *slightly disagree*, 3 = *neither agree nor disagree*, 4 = *slightly agree*, and 5 = *strongly agree*. ^bAt the 6- to 12-month follow-up participants were asked, "How high or low are the chances that you would get cholera this year?" The answering options were as follows: 1 = *very low*, 2 = *low*, 3 = *neither low nor high*, 4 = *high*, and 5 = *very high*. ^cThe answering options were as follows: 1 = *not sure at all*, 2 = *not sure*, 3 = *neither sure nor not sure*, 4 = *a little sure*, and 5 = *very sure*.

Table 3. Simple Mediation Results for Psychosocial Factors at 1-Week Follow-Up for Handwashing With Soap by Study Arm (N = 186).^a

Factor category	Statement	a Path ^b	b Path ^c	Indirect effects (c' = a × b path; 90% confidence interval)		
				c'	Lower limit	Upper limit
Remembering	It is hard to remember to wash your hands with soap after using the toilet.	-0.35*	-0.20	0.07	-0.003	0.24
Remembering	It is hard to remember to wash your hands with soap before preparing a meal.	-0.77*	-0.15	0.11	-0.05	0.37
Perceived Susceptibility	When your family member with cholera returned home from the hospital, how high or low were the chances that <i>you</i> would contract cholera?	0.05	0.02	0.00	-0.08	0.12
Perceived Susceptibility	When your family member with cholera returned home from the hospital, how high or low were the chances that <i>your other family members</i> would contract cholera?	-0.05	-0.08	0.00	-0.04	0.11
Cholera Awareness	Can you name three important ways cholera can be prevented? Can you please name the four key times for handwashing with soap? Can you name three important ways cholera is spread?	2.23*	-0.11	-0.24	-0.85	0.31
Dirt Reactivity	You only wash your hands with soap when they have a bad smell.	-0.37*	0.19	-0.018	0.40	0.01
Disgust	You feel your hands are disgusting after cleaning up a child's feces.	0.18	0.20	0.04	0.00	0.19
Response Efficacy	If you always wash your hands with soap what are the chances you will develop cholera?	-0.17*	-0.74	0.12	0.004	0.40
Convenience	You have no time to wash your hands with soap.	-0.40*	-0.13	0.05	-0.05	0.24

^aHandwashing with soap defined as handwashing with soap event at a key time during the 5-hour structured observation period. Key times are defined as after using the toilet or cleaning a child's anus and before eating or preparing food. 90% Confidence intervals for indirect effects were calculated using bootstrapping. ^ba path = effects of the intervention on the mediators (psychosocial factors). ^cb path = effects of the mediators (behavioral factors) on handwashing with soap with study arm in the model (boldface indicates significant effects).

*p ≤ .05, one-tailed.

with soap we could be eating feces that has cholera.” Our finding is consistent with Contzen and Mosler (2015) who found that disgust was significantly associated with handwashing with soap behavior in studies conducted in both Haiti and Ethiopia. This result is also consistent with an intervention study conducted in Australia that found a disgust-based intervention to be significantly more effective in increasing acts of hand hygiene compared to one focusing on hand hygiene information alone (Porzig-Drummond, Stevenson, Case, & Oaten, 2009). In Nizame et al. (2013), disgust was ranked by caregivers to be the second best motivator to encourage handwashing with soap; nurture was the first. Furthermore, a review by Curtis, Danquah, and Aunger (2009) concluded that handwashing with soap interventions should focus on disgust and social norms. Our results, however, need to be approached with caution given that a single item was used to measure a factor that is typically measured using several items (de Barra, Islam, & Curtis, 2014). Future studies are needed that measure this factor using multiple items.

Convenience was also found to mediate the effect of the CHoBI7 intervention at the 6- to 12-month follow-up. The

behavior change technique used to target convenience was enabling technology, which included a handwashing station and a soapy water bottle delivered by a promoter. This technology was selected based on previous formative research informed by the IBM-WASH model (Hulland et al., 2013). The decision to include soapy water, a low-cost alternative to soap, was also informed by a previous study in Kenya that found lack of concern about the cost of soap to be associated with observed handwashing with soap behavior (Biran et al., 2014). Our results are consistent with previous studies that have found handwashing stations to facilitate handwashing with soap behaviors (Curtis et al., 2009; Dreifelbis et al., 2013; Hulland et al., 2013).

Cholera awareness mediated the effect of the CHoBI7 intervention at the 6- to 12-month follow-up. This finding suggests that cholera awareness was a key factor in the underlying change process of the CHoBI7 intervention and has an important role in the maintenance of handwashing with soap behavior. This is in contrast to previous studies that found knowledge of diarrhea prevention to not be associated with hand hygiene practice and to a recent study in Haiti, which found that health knowledge was negatively

Table 4. Simple Mediation Results for Psychosocial Factors at the 6- to 12-Month Follow-Up for Handwashing With Soap by Study Arm (N = 125).^a

Factor category	Statement	a path ^b	b path ^c	Indirect effects (c' = a × b path; 90% confidence interval)		
				c'	Lower limit	Upper limit
Remembering	It is hard to remember to wash your hands with soap after using the toilet.	-0.41	-0.11	0.05	-0.04	0.30
Remembering	It is hard to remember to wash your hands with soap before preparing a meal.	-0.65*	0.14	-0.09	-0.32	0.01
Remembering	Seeing soap after using the toilet makes you wash your hands.	-0.02	-0.18	0.00	-0.06	0.09
Perceived Susceptibility	How high or low are the chances that you will get cholera this year?	-0.20	0.33	-0.07	-0.33	0.02
Cholera Awareness	Can you name three important ways cholera can be prevented? Can you please name the four key times for handwashing with soap? Can you name three important ways cholera is spread?	1.28*	0.20*	0.26	0.03	0.60
Disgust Reactivity	You only wash your hands with soap when they have a bad smell.	-0.90*	-0.11	0.09	-0.09	0.35
Disgust	You feel your hands are disgusting after cleaning up a child's feces.	0.62*	0.49	0.31	0.03	0.88
Response Efficacy	If you always wash your hands with soap what are the chances you will develop cholera?	-0.20	-0.06	0.01	-0.09	0.26
Convenience	You have no time to wash your hands with soap.	-0.60*	0.16	-0.10	-0.35	0.07
Convenience	It is inconvenient to always wash hands with soap.	-0.47*	0.34*	-0.16	-0.45	-0.02
Self-Efficacy	If someone in your home gets cholera, how sure are you that you can prevent the spread of cholera?	0.40*	-0.10	-0.04	-0.17	0.12
Self-Efficacy	How sure are you that you can make handwashing with soap available for your family every day?	0.15*	0.4308	0.06	-0.23	3.53
Self-Efficacy	How sure are you that you can always wash your hands with soap before eating?	0.44*	0.19	0.08	-0.10	0.33

^aHandwashing with soap defined as handwashing with soap event at a key time during the 5-hour structured observation period. Key times are defined as after using the toilet or cleaning a child's anus and before eating or preparing food. 90% Confidence Intervals for indirect effects were calculated using bootstrapping. ^ba path = effects of the intervention on the mediators (psychosocial factors). ^cb path = effects of the mediators (behavioral factors) on handwashing with soap with study arm in the model (boldface indicates significant effects).

*p ≤ .05, one-tailed.

associated with handwashing with soap after stool-related events (Biran et al., 2009; Contzen & Mosler, 2015; De Wandel, Maes, Labeau, Vereecken, & Blot, 2010). Hirai et al. (2016), however, found that preventing the spread of disease was a significant motivator for handwashing with soap in Indonesia.

Intervention household members were found to have significantly less difficulty remembering to wash their hands with soap than control household members at both the 1-week and 6- to 12-month follow-up. The behavior change technique used to target this factor was a poster with the promoted key times to wash hands with soap. In addition, the presence of the handwashing station itself may have also served as a reminder, or cue to action, to household members to wash hands with soap at key times. The inclusion of this behavior change technique was informed by Tobias (2009), who found that development of habits

depends on the availability of reminders to increase remembering. In a recent trial conducted in Ethiopia, remembering was found to mediate the effect of a handwashing with soap intervention (Contzen & Inauen, 2015). While remembering was not found to be a significant mediator in our intervention study, it may present a promising target for future interventions.

The CHoBI7 intervention significantly increased dirt reactivity at the 6- to 12-month follow-up. We defined dirt reactivity as washing hands with soap only in response to dirt, feces, or smell. Previous qualitative research has described the concept of dirt reactivity (Scott, Curtis, Rabie, & Garbrah-Aidoo, 2007; Whitby, McLaws, & Ross, 2006). In Whitby et al. (2006) and Scott et al. (2007), smell and a "gross feeling" on hands were key motivators of handwashing with soap practices. In Hirai et al. (2016), getting rid of dirt, smells, or sticky things was a significant motivator of

handwashing with soap in Indonesia. The behavior change technique used to target dirt reactivity was a pictorial module delivered by a promoter stating, "Cholera has no taste or smell its invisible therefore visibly clean hands can have cholera." Our goal was to encourage household members to *always* wash their hands with soap, *not* only in response to dirt reactivity. Future studies should investigate the role of dirt reactivity on handwashing with soap behavior using more items to measure this factor.

Self-efficacy was significantly higher among intervention household members compared to controls at the 6- to 12-month follow-up. However, this factor was not found to be a mediator of handwashing with soap behavior. One potential explanation for this finding is the high self-efficacy (>4.3) observed in *both* study arms which left little scope to improve this factor. Self-efficacy was targeted through enabling technology, which included the distribution of a handwashing station and soapy water bottle by a promoter to facilitate handwashing with soap behaviors. Previous studies have found self-efficacy to be significantly associated with handwashing with soap behaviors (Contzen & Inauen, 2015; Contzen & Mosler, 2015; De Wandel et al., 2010).

There was no significant difference in perceived susceptibility in the CHoBI7 arm compared to the control arm. This factor was targeted through a pictorial module delivered by a promoter stating, "Because someone in your family got cholera you are at a very high risk of developing cholera for the next 7 days." One potential explanation for this finding is that all study participants lived in a household with a cholera patient and therefore were already aware of their high susceptibility to cholera. Furthermore, the literature indicates that although protection from disease is a factor in an individual's decision to wash his or her hands with soap, it is often not a *key* motivator (Contzen & Mosler, 2015; Scott et al., 2007; Whitby et al., 2007).

This study has several strengths. First is the use of structured observation to assess observed handwashing with soap behavior. Second, psychosocial factors were measured at 1 week and 6 to 12 months after enrollment. This allowed us to assess factors associated with handwashing with soap habit formation *and* maintenance. Third, the cluster RCT study design resulted in study arms with no significant differences in psychosocial factors at baseline. Fourth, the use of a mediation analysis allowed us to investigate the underlying mechanism of change for the CHoBI7 intervention.

This study also has limitations that should be considered when interpreting the study findings. First, we used a single item to measure many factors. This was done due to time constraints of the study team. However, previous work from Rossiter (2011) and Abraham (2012) emphasize content validity over the number of items used to measure constructs. The implications of using a single item for many factors are unknown. Future studies should use several items with high content validity to measure each factor. Second, our small

sample size during our structured observation sessions limited our ability to conduct a mediation analysis that distinguished between stool- and food-related events. Third, the use of structured observation has the theoretical possibility of a Hawthorne effect. Fourth, CHoBI7 combined both a handwashing with soap *and* water treatment intervention. This was done given the strong evidence base supporting both person-to-person and environmental transmission of cholera (Harris et al., 2008; Hughes et al., 1982; Sinclair et al., 1982; Weil et al., 2009).

Conclusion

In conclusion, through conducting a theory-based WASH intervention trial we were able to identify the psychosocial factors mediating the high efficacy of the CHoBI7 intervention and to recommend factors that can be targeted in future interventions. This study demonstrates the importance of using theory-driven approaches for the development and implementation of handwashing with soap interventions.

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Supplemental Material

Additional supporting information is available at heb.sagepub.com/supplemental.

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