



Identifying psychosocial determinants of water, sanitation, and hygiene (WASH) behaviors for the development of evidence-based Baby WASH interventions (REDUCE program)

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ABSTRACT

Diarrheal disease remains a leading cause of child mortality, globally. In the Democratic Republic of the Congo (DRC), each year there are an estimated 45 million episodes of diarrhea in children under five years of age. The Reducing Enteropathy, Diarrhea, Undernutrition, and Contamination in the Environment (REDUCE) program seeks to develop theory-driven, evidence-based approaches to reduce diarrheal diseases among young children. The REDUCE prospective cohort study in Walungu Territory in Eastern DRC took guidance from the risks, attitudes, norms, abilities, and self-regulation model, the integrated behavioral model for water, sanitation, and hygiene (WASH), and other behavior change theories to identify psychosocial factors associated with WASH behaviors. Psychosocial factors were measured among 417 caregivers at baseline and caregiver responses to child mouthing of dirty fomites and handwashing with soap was assessed by 5-hour structured observation at the 6-month follow-up. Caregivers who agreed that their child could become sick if they put dirt in their mouth (perceived susceptibility) and caregivers that agreed they could prevent their child from playing with dirty things outside (self-efficacy) were significantly more likely to stop their child from mouthing a dirty fomite. Higher perceived susceptibility, self-efficacy, and disgust, and lower dirty reactivity, were associated with higher handwashing with soap behaviors. This study took a theory-driven and evidence-based approach to identify psychosocial factors to target for intervention development. The findings from this study informed the development of the REDUCE Baby WASH Modules that have been delivered to over 1 million people in eastern DRC.

1. Introduction

Globally, diarrheal disease is a leading cause of mortality for children under five years of age, resulting in nearly 450,000 deaths annually (Collaborators 2018). In the Democratic Republic of the Congo (DRC), there are an estimated 45 million episodes of diarrhea annually in children under the age of 5, resulting in 19,000 deaths (Collaborators 2017). Interventions targeting handwashing with soap before food preparation and after toileting events can reduce the risk of diarrheal disease by 23% (WHO 2014). However, only 19% of the world population washes their hands after contact with human excreta (Prüss-Ustün et al., 2014).

Diarrheal diseases are often transmitted through fecal-oral pathways through ingestion of unclean food and water, and dirty fomites, fingers, and dirt (Wagner and Lanoix 1958). However, most WASH interventions focus on sanitation, water treatment, and/or hand hygiene and often do not emphasize the risk of diarrheal diseases associated with contact with animal feces, such as mouthing dirty fomites and soil (Null et al., 2018; Pickering et al., 2019). The Global Burden of Disease (GBD) study estimated that pathogens that cross the zoonotic barrier are responsible for 28% of diarrheal deaths in children under five (Collaborators, 2016). Recent literature suggests that intervention studies should consider other transmission routes beyond traditional WASH improvements for reducing child diarrheal diseases (Budge et al., 2019; Kwong et al., 2020;

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Ngure et al., 2014; Prendergast et al., 2019). Multiple studies have provided evidence that enteropathogen exposure through child mouthing of dirty fomites and soil can have adverse health outcomes (Delahoy et al., 2018; George et al., 2021; Investigators 2018; Kotloff et al., 2013; Morita et al., 2017). Therefore, effective WASH interventions are needed to target these important fecal exposures pathways for young children.

WASH interventions that incorporate elements of psychosocial theory and target multiple behavioral determinants are more likely to be effective than interventions that seek to promote WASH behavior change by providing information alone (Briscoe and Aboud 2012; Curtis et al., 2011; De Buck et al., 2018). Theory-driven interventions take guidance from behavior change theories and frameworks to identify factors likely to drive, facilitate, or impede behavior change; these factors are often referred to as psychosocial determinants. Some examples of behavior change theories and theory-based approaches for WASH intervention development include protection motivation theory, the health belief model, the integrated behavioral model for water, sanitation, and hygiene (IBM-WASH), the risks, attitudes, norms, abilities, and self-regulation (RANAS) model, the Behavior Center Design (BCD) Behavior Determination Model, and the Focus, Opportunity, Ability and Motivation (FOAM) framework (Aunger and Curtis, 2019; Daniel et al., 2019; Devine et al., 2012; Dreifelbis et al., 2013; Le and Makarchev 2020; Mosler 2012; Prentice-Dunn and Rogers 1986; Rainey and Harding 2005). Identifying the psychosocial determinants of a target behavior, such as handwashing with soap, can inform intervention development through the selection of behavior change techniques to target determinants (Michie and Abraham 2004; Mosler 2012).

The objectives of the Reducing Enteropathy Undernutrition and Contamination in the Environment (REDUCE) program were to: 1) identify fecal exposure pathways that contribute to diarrheal disease, child growth, and child cognitive development in young children in the DRC and 2) develop theory-driven and evidence-based interventions to reduce child morbidity via these pathways. The REDUCE cohort study found that child mouthing of contaminated fomites, *E.coli* in soil and on child hands, and child contact with animals was associated with subsequent diarrhea, impaired child growth, and adverse child cognitive developmental outcomes (George et al., 2021b; George et al., 2021). In order to inform an intervention to address these risk factors identified during the REDUCE cohort study, the objective of this study was to identify psychosocial determinants of two target WASH behaviors: 1) handwashing with soap by caregivers at stool- and food-related events and 2) caregivers stopping a child from mouthing dirty fomites (soil and contaminated surfaces and objects).

2. Methods

2.1. Study design

This prospective cohort study of 417 caregivers of young children was conducted in the Walungu Territory, South Kivu, DRC as part of the REDUCE program. This study enrolled households with at least one child under the age of five years and followed these households for 6 months. The sample size for this analysis was based on the number of caregivers of children under five years of age that were enrolled between June 2018 and January 2019 that had WASH psychosocial factor questionnaire data at baseline and had 5-hour structured observation data available at the 6-month follow-up.

2.2. Questionnaire

At baseline, 15 research assistants, after receiving a 2 month training, administered a structured psychosocial factor questionnaire to caregivers (12 years or older) of a child under five years of age. Items (e. g., "It is difficult to watch children when they are playing outside in the dirt.") to measure psychosocial factors were informed by protection

motivation theory (response efficacy), the RANAS model, IBM-WASH, and previous work done by our group on determinants of handwashing with soap (Dreifelbis et al., 2013; George et al., 2017a; Mosler 2012; Prentice-Dunn and Rogers 1986). Using the three models, we developed an approach that incorporates psychosocial factors over multiple levels of influence. All items related to child mouthing were developed for this study. To save time spent in the household, most psychosocial factors were measured with a single item. We assessed the following psychosocial factors: impediments, instrumental attitudes, descriptive norms, injunctive norms, dirt reactivity, disgust, perceived severity, perceived susceptibility, remembering, response efficacy, and self-efficacy. Definitions of each factor are in Table 1.

Psychosocial factor questionnaire items were developed in English, translated into the Bukavu dialect of Swahili, and back translated into English in two iterations. The questionnaire was piloted with 99 individuals before the cohort study and six interviews were conducted with verbal probing techniques, where participants were asked to re-explain the questions back to the interviewer to explore the comprehension of questionnaire items and reasons for a participant's responses (Willis and Artino, 2013). We then conducted a focus group discussion (FGD) with mothers of young children to further refine items and response options. Psychosocial items were modified based on piloting, interviews, and FGD findings, as well as concurrent formative research refers to Kuhl et al. (2021) ahead of inclusion in the final questionnaire for the cohort study (Kuhl et al., 2021). Response options for each item were a Likert-type scale ranging from one to five (e.g., 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree).

2.3. Structured observations

A trained research assistant conducted a 5-hour structured observation using a structured questionnaire form at the 6-month follow-up. Observations took place between the hours of 8:00 a.m. and 1:00 p.m. to include as many household members as possible and to ensure that timing for observations was standardized across all households. The

Table 1

Psychosocial factors in behavior change theories, including risk, attitude, norm, ability, and self-regulation (RANAS) model and integrated behavior model in WASH of behavior change and their definition.

Factors	Definition
Impediments	Anticipated barriers and distractions to a behavior (Contzen et al., 2015)
Instrumental Attitudes	Beliefs about the benefits and costs of a behavior (Fishbein and Ajzen, 1977)
Descriptive Norms	Perceptions about which behaviors are typically performed by others (Mosler, 2012)
Dirt Reactivity	Only washing hands with soap in response to dirt, feces, or smell (George et al., 2017a)
Disgust	Revulsion that is occasioned by the sight of excreta, rotten food, slime, and bugs (Curtis and Biran, 2001)
Injunctive Norms	Perceptions of which behaviors are typically approved or disapproved of by relatives, friends, or neighbors (also the dos and don'ts expressed by religious, civil or other institutional leaders) (Schultz et al., 2007)
Perceived Severity	A person's perception of the seriousness of the consequences of contracting an illness (Prentice-Dunn and Rogers, 1986)
Perceived Susceptibility	A person's perception of his or her risk of contracting diarrheal disease and other illnesses (Orbell et al., 2009)
Remembering	To perform a behavior, it has to be remembered at the right time/situation (Tobias, 2009)
Response Efficacy	Judgments about the efficacy of a preventive response that will avert the perceived threat (Prentice-Dunn and Rogers, 1986)
Self-efficacy	The belief in one's capabilities to organize and execute the courses of action required to manage prospective behaviors; the ability to deal with barriers that arise when trying to maintain the behavior (Bandura, 1997)

research assistant sat in a part of the household defined as a common living space used for cooking, sleeping, and other indoor/outdoor activities to observe household activities with minimal movement and interaction with the household members. Households were informed that research assistants were observing daily activities, without specifying WASH-related events to reduce the Hawthorne effect (Adair 1984).

Child mouthing events. For child mouthing events, research assistants recorded whether a child under five years of age put food or dirty fomites in their mouth during the structured observation period. A dirty fomite was defined as a child putting mud, soil, clay, sand, feces, or an object or surface with visible dirt to or inside their mouth. The object was considered visibly dirty if it had visible mud, soil, clay, sand, or feces on its surface. Information was also collected on whether a caregiver over the age of 12 years stopped a child from mouthing a dirty fomite during structured observation, defined as a participant: 1) physically stopping the child from putting the substance in their mouth, 2) physically stopping the child from handling the dirty fomite, 3) removing the dirty fomite from the child's mouth, or 4) removing the substance from the child's hand.

Handwashing at food- and stool-related events. During structured observation, research assistants recorded handwashing practices for caregivers 12 years of age or older at the following stool- and food-related events: (1) before preparing food, (2) before eating, (3) before serving food/feeding a child, (4) after a toileting event, defined as after use of a sanitation option (e.g., toilet or improved or unimproved latrine), after cleaning a child's anus after a defecation event, and (6) after disposal/removal of child feces.

2.4. Statistical analysis

All statistical analyses were conducted in SAS Version 9.4 (SAS Institute Inc., Cary, NC). Pearson correlations were calculated for psychosocial factors at baseline. Our handwashing with soap outcome was a binary variable defined as a caregiver washing both hands with soap during a food- or stool-related event at least once during structured observation. Our caregiver response to a child mouthing event outcome was a binary variable defined as a caregiver stopping a child from mouthing a dirty fomite at least once during the 5-h structured observation. Logistic regression models using generalized estimating equations to account for clustering within households were conducted to estimate the odds of caregivers handwashing with soap at key events and stopping a child from mouthing a dirty fomite event at least one time during 5-h structured observation at the 6-month follow-up, with psychosocial items at baseline as predictors. Responses to psychosocial items were transformed to a scale of 0–1 by dividing each Likert-type scale response by 5 for regression analyses to make odds ratios easier to interpret (e.g., observed behavior associated with the participant strongly agreeing with a psychosocial item).

2.5 Ethical approval

Informed consent was obtained by all study participants. If the participant was between 12 and 17 years old, assent was obtained along with parental permission from the child's guardian. This study was approved by the research ethical review committee of the University of Kinshasa (Protocol 043–2017) and the Johns Hopkins Bloomberg School of Public Health (Protocol 8057).

3. Results

3.1. Characteristics and demographics of study participants

From June 2018 to January 2019, 417 caregivers over the age of 12 years with at least one child under the age of five years were enrolled in the cohort study and administered the structured psychosocial factor questionnaire at baseline. There were 50 participants who did not have

data at the 6-month follow-up (12% (50/417) loss to follow up). The mean age of participants was 30 years (standard deviation: 13, range 12–84) and 82% (340/417) were female. Among study participants, 67% (280/417) of caregivers had at least a primary-school level of education. There were 209 caregivers who had both handwashing at key events and child mouthing events during 5-hour structured observations. Baseline demographics and characteristics can be found in Table 2.

3.2. Analysis of psychosocial factors

The two largest Pearson correlation for psychosocial items at baseline were perceived susceptibility and dirt reactivity (Supplementary Tables 1 and 2).

3.3. Participants stopping a child mouthing a dirty fomite

Two hundred thirty-nine caregivers were present during a child mouthing event during structured observation at the 6-month follow-up. Thirty-nine percent (93/239) of these caregivers stopped a child at least once from mouthing a dirty fomite during structured observation. Caregivers who agreed that a child could become sick if they put dirt in their mouth (perceived susceptibility) were more likely to stop a child from mouthing a dirty fomite (Odds Ratio (OR) = 1.28 95% Confidence Interval (CI) = 1.02–1.61). Caregivers who were sure they could prevent their child from playing with dirty things outside were more likely to stop a child from mouthing a dirty fomite (OR = 1.21; 95% CI = 1.01–1.44) (Table 3).

3.4. Handwashing with soap at food- and stool-related events

Two hundred twenty caregivers had a stool- or food-related event during structured observations at the six-month follow-up. Fourteen percent (30/220) of these caregivers washed both of their hands with soap at least once during these events. Caregivers who felt compelled to wash their hands with soap after toileting due to disgust (OR = 1.85 (95% CI = 1.04, 3.30) (disgust) were more likely to wash both hands

Table 2

Baseline demographics and characteristics among caregivers of children under five years in Walungu, South Kivu, Democratic Republic of the Congo.

	%	n
Caregivers		417
Caregiver baseline age (years) Median SD (min-max)	30 ± 13 (12–84)	
Households		261
Children <5 years		465
Caregiver any formal education	67%	280
Gender		
Female	82%	340
Household wall type		
Mud walls	59%	154
Wood walls	7%	18
Concrete walls	4%	10
Wood and mud walls	4%	11
Biomass walls	5%	12
Brick walls	3%	8
Wood and concrete walls	1%	3
Other	20%	53
Household animal ownership	52%	135
Unimproved latrine	92%	239
Water source type		
Protected spring	62%	162
Public tap	23%	59
Unprotected spring	4%	10
Other	5%	13
Household size Median SD (min-max)	6 ± 2.4 (2–17)	

SD: standard deviation; unimproved latrine: use of pit latrines without a slab or platform, hanging latrines, or bucket latrines; any formal education: primary, secondary, or not finished secondary school.

Table 3

Logistic regression analysis of psychosocial factors (predictor) and caregivers atopping a child during a mouthing of a dirty fomite event (outcome) during 5-hour structured observation (N = 239).

Factor Category	^a Item	M	SD	OR (95% CI)
<i>Impediments</i>	It is difficult to watch children when they are playing outside in the dirt	3.57	1.58	1.00 (0.85, 1.17)
<i>Descriptive Norms</i>	Most of (many among) the people in your village let their young children eat dirt	4.03	1.36	0.95 (0.80, 1.13)
<i>Perceived Severity</i>	If your child(ren) less than 2 years of age gets diarrhea, how severely would that impact your life?	4.43	1.18	1.04 (0.83, 1.29)
	^b How likely is it that someone who develops diarrhea will die?	4.42	1.10	0.86 (0.69, 1.07)
<i>Perceived Susceptibility</i>	It is not harmful for a child to play outside in the dirt	2.9	1.72	0.87 (0.75, 1.01)
	It is not harmful for a child to eat dirt	2.44	1.66	0.90 (0.77, 1.06)
	It is not harmful for children to pick up used wrappers or bottles from the ground and put them in their mouths	2.42	1.63	0.94 (0.80, 1.10)
	Eating dirt is good for your child's health	1.77	1.3	1.12 (0.75, 1.10)
	Your child will become sick if they put dirt in their mouth	4.31	1.18	1.33 (1.04, 1.69)
	There is no need to clean up after a child defecates in the dirt	2.62	1.67	0.90 (0.78, 1.05)
	How likely is it that your child will develop diarrhea in the next month? Do you think it is unlikely or likely?	3.53	1.37	1.12 (0.93, 1.33)
<i>Self-efficacy</i>	^c How sure are you that you can protect your child from getting diarrhea?	3.50	1.51	1.2 (1.00, 1.44)
	^c How sure are you that you can prevent your child from eating dirt?	3.21	1.53	1.09 (0.91, 1.29)
	^c How sure are you that you can prevent your child from playing with dirty things outside?	3.24	1.51	1.21 (1.01, 1.44)

M: Mean (Likert-scale); SD: Standard Deviation; OR: Odds Ratio; L95%CI: Lower 95% Confidence Interval, U95%CI: Upper 95% Confidence Interval; Boldface indicates significant effects $p < 0.05$; ^aFactors are ordinal and range from 1 to 5 based on responses to psychosocial questions. Answering options were as follows unless otherwise noted: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree; ^bThe answering options were as follows: 1 = extremely unlikely, 2 = unlikely, 3 = neither likely nor unlikely, 4 = likely, 5 extremely likely; ^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.

Table 4

Logistic regression analysis of psychosocial factors (predictor) and handwashing with soap at a key stool- or food-related event (outcome) during 5-hour structured observation (N = 220).

Factor Category	^a Item	M	SD	OR (95% CI)
<i>Impediments</i>	If you put soap near the latrine (WC) people will steal it	3.86	1.50	1.00 (0.77, 1.31)
	You have a specific place in your home to wash your hands with soap	2.64	1.75	1.17 (0.94, 1.46)
	It is hard to find water to wash hands with soap	2.27	1.47	0.98 (0.80, 1.20)
<i>Convenience</i>	You have too little time to wash your hands with soap	3.54	1.49	0.97 (0.73, 1.30)
<i>Descriptive Norms</i>	Most of (many among) your neighbors don't wash their hands with soap	3.99	1.32	0.93 (0.70, 1.24)
<i>Dirt Reactivity</i>	If your hands look clean, there are no germs on them	2.93	1.69	0.99 (0.75, 1.32)
	You only wash your hands with soap when they have dirt on them	3.53	1.61	0.83 (0.66, 1.04)
	You only wash your hands with soap when they are sticky (when they have sticky things on them)	3.37	1.65	0.90 (0.72, 1.13)
	You only wash your child's hands with soap when they are sticky (when they have sticky things on them)	3.42	1.62	0.75 (0.59, 0.95)
	You only wash your child's hands with soap when they have dirt on them	3.43	1.60	0.76 (0.59, 0.96)
<i>Disgust</i>	After toileting (using the WC), you are compelled to wash your hands with soap because you feel your hands are disgusting	4.10	1.34	1.85 (1.04, 3.30)
	You feel your hands are disgusting after cleaning up a child's feces	3.50	1.61	1.31 (1.00, 1.73)
<i>Injunctive Norms</i>	Visitors will respect you if they find a place to wash hands with soap at your home	4.38	1.09	1.05 (0.72, 1.53)
<i>Instrumental Attitudes</i>	It is burdensome to always wash your hands with soap (every time and every day)	3.28	1.60	0.96 (0.77, 1.21)
	Soap is too costly to use for handwashing	3.38	1.60	0.86 (0.67, 1.10)
	You do not have enough time to wash your child's hands with soap	3.38	1.48	0.99 (0.80, 1.23)
<i>Perceived Severity</i>	If your child(ren) less than 2 years of age gets diarrhea, how severely would that impact your life?	4.43	1.18	0.94 (0.67, 1.31)
	^b How likely is it that someone who develops diarrhea will die?	4.42	1.10	1.15 (0.77, 1.71)
<i>Perceived Susceptibility</i>	^b How likely is it that your child will develop diarrhea in the next month?	3.53	1.37	1.43 (1.02, 2.00)
<i>Remembering</i>	It is hard to remember to wash your hands with soap while preparing a meal	3.48	1.51	0.88 (0.71, 1.10)
	Washing your hands with soap after using the toilet (WC) is hard to remember	3.17	1.61	0.95 (0.73, 1.22)
	It is hard to remember to wash your child's hands with soap	3.18	1.56	1.21 (0.92, 1.57)
<i>Response Efficacy</i>	^b How likely is it that your child will get diarrhea if you always (every time and every day) wash your hands with soap?	3.31	1.49	0.97 (0.78, 1.20)
<i>Self-efficacy</i>	^c How sure are you that you can make soap for handwashing available for your family every day?	3.46	1.48	1.08 (0.85, 1.37)
	^c How sure are you that you can always (every time and every day) wash your hands with soap after using the toilet (after WC)?	3.86	1.35	1.41 (1.01, 1.98)
	^c How sure are you that you can always (every time and every day) wash your hands with soap before feeding your child?	4.08	1.30	1.50 (1.02, 2.18)
	^c How sure are you that you can protect your child from getting diarrhea?	3.50	1.51	1.19 (0.92, 1.53)

M: Mean (Likert-scale); SD: Standard Deviation; OR: Odds Ratio; L95%CI: Lower 95% Confidence Interval, U95%CI: Upper 95% Confidence Interval; Boldface indicates significant effects $p < 0.05$; ^aFactors are ordinal and range from 1 to 5 based on responses to psychosocial questions. Answering options were as follows unless otherwise noted: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree; ^bThe answering options were as follows: 1 = extremely unlikely, 2 = unlikely, 3 = neither likely nor unlikely, 4 = likely, 5 extremely likely; ^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.

with soap during key handwashing events at the 6-month follow-up. Caregivers who agreed that they could always wash their hands with soap after a toileting event were more likely to wash both hands with soap (OR = 1.41 (95% CI = 1.01–1.98)) (self-efficacy). Caregivers who agreed they could always wash their hands with soap before feeding their child were more likely to wash their hands with soap (OR = 1.50, (95% CI = 1.02–2.18)) (self-efficacy). Caregivers who agreed that they only wash their child's hands when they are sticky (OR = 0.75 (95% CI = 0.59–0.95)) or have dirt on them (OR = 0.76, 95% CI = 0.69–0.96) (dirt reactivity) were less likely to wash their own hands with soap. Caregivers who agreed their child was likely to develop diarrhea in the next month were more likely to wash their own hands with soap (OR = 1.43, (95% CI = 1.02–2.00) (Table 4).

4. Discussion

This prospective cohort study investigated the psychosocial determinants of stopping a child from mouthing a dirty fomite and handwashing with soap at stool- and food-related events among caregivers with a young child in their household in rural DRC. Caregivers who believed a child would become sick if the child put dirt in their mouth (high perceived susceptibility) and who were sure they could prevent a child from playing with dirty things outside at baseline (higher self-efficacy) were more likely to stop a child from mouthing a dirty fomite during structured observation at the 6-month follow-up. Higher baseline self-efficacy and higher perceived susceptibility around handwashing with soap at key food- and stool-related events were associated with increased handwashing with soap at the 6-month follow-up. Caregivers who said that they only washed their child's hands when they appeared dirty or sticky (high dirt reactivity) were less likely to wash their own hands with soap. However, those that felt their hands were disgusting after coming into contact with feces were more likely to wash their hands with soap at follow-up. This is the first published study, to our knowledge, investigating WASH psychosocial factors associated with caregivers' response to child mouthing behaviors. This study took a theory-driven and evidence-based approach to identify psychosocial factors to target for intervention development. These findings were applied to develop the REDUCE Baby WASH intervention modules that have been delivered to over 1 million people in South Kivu and Tanganyika provinces of DRC Kuhl et al. (2021).

Higher perceived susceptibility and higher self-efficacy related to child mouthing practices were associated with a caregiver stopping a child from mouthing a dirty fomite in our cohort study. The only other paper to our knowledge that has investigated psychosocial factors related to child mouthing behaviors is Wodnik et al., who developed items using the Capability Opportunity Motivation and Behavior (COM-B) model on provision of a safe play environment for children in Kenya (Wodnik et al., 2018). However, this previous study did not investigate the association between caregivers' responses to child mouthing behaviors and WASH psychosocial determinants. Previous studies in rural Bangladesh have found that child mouthing behavior of soil and dirty fomites is associated with environmental enteropathy and impaired growth in children under five years (Morita et al., 2017). Additionally, studies in urban Kenya and rural Ghana found an association between mouthing soil and diarrhea (Bauza et al. 2017, 2018). These findings emphasize the need for studies to identify the psychosocial determinants driving participant responses to child mouthing behaviors to develop interventions that target reducing child mouthing of dirty fomites.

The finding that perceived susceptibility and higher self-efficacy were psychosocial determinants of stopping children from mouthing dirty fomites informed the development of the REDUCE Baby WASH Child Mouthing Module. A pictorial flipbook delivered by a health promoter was developed targeting perceived susceptibility of diarrheal diseases from child mouthing practices through images of worms in the stomach of a child that mouthed dirty fomites, and a story of a child that mouthed dirt and then had to be admitted to the hospital with severe

diarrhea. A locally-sourced play mat was also provided to create an enabling environment which made it easier for caregivers to keep young children off the ground to reduce child contact with contaminated soil in their environment (Kuhl et al., 2021). Caregivers reported that playmats reduced child mouthing of dirty fomites and enabled caregivers to have more ease when conducting household chores, since they knew their young child was sitting on the playmat (self-efficacy) (Kuhl et al., 2021).

Higher self-efficacy was found to be associated with handwashing with soap in our cohort study. These findings are consistent with the current literature demonstrating that perceived severity and self-efficacy are important psychosocial determinants of handwashing with soap behaviors (Contzen and Inauen 2015; Contzen et al., 2015; De Wandel et al., 2010; Scott et al., 2007). A study in Ethiopia and Haiti found that higher self-efficacy was positively associated with handwashing with soap behaviors at food- and feces-related events (Contzen and Inauen 2015; Contzen and Mosler 2015). However, this study was cross-sectional and used self-reported handwashing with soap behaviors instead of structured observation. In our recent randomized controlled trial (RCT) of the CHoBI7 WASH mobile health program, we found self-efficacy was a significant mediator of handwashing with soap habit maintenance at the 12-month follow-up (George et al., 2021a). These findings highlight the need to target self-efficacy in handwashing with soap interventions.

Our finding that disgust was significantly associated with higher handwashing with soap behaviors among caregivers is consistent with findings from Contzen et al. in Ethiopia and Haiti (Contzen and Mosler 2015). This result is also consistent with a study conducted in Kenya, which found that disgust was a motivating factor for handwashing with soap behaviors (Aunger et al., 2010). Porzig-Drummond et al. reported that disgust-based interventions were significantly more effective in increasing handwashing with soap behaviors compared to education- and technology-only hand hygiene interventions (Porzig-Drummond et al., 2009). An eleven-country review of determinants of handwashing with soap found disgust to be a key motivator of handwashing with soap behavior (Curtis et al., 2009). In our previous RCT in Bangladesh, disgust was a significant mediator of handwashing with soap habit maintenance (George et al., 2017a). These findings demonstrate the important role of disgust in facilitating handwashing with soap behaviors.

High dirt reactivity was found to reduce handwashing with soap behavior among caregivers in our cohort study. Dirt reactivity can be an important barrier for handwashing with soap, as people will only wash their hands when their hands look dirty, rather than washing them during all key handwashing events. Previous qualitative research has found that olfactory cues and feeling dirty are key contributors to handwashing with soap behaviors (Scott et al., 2007). Our findings are consistent with a study in Indonesia, where hands feeling dirty was a key motivator for handwashing with soap (Hirai et al., 2016). Our previous RCTs in Bangladesh also found high dirt reactivity to be associated with less handwashing with soap (George et al., 2017a; George et al., 2021a). Our findings suggest that reducing hand-dirt reactivity as a barrier could improve handwashing with soap at food- and stool-related events. The role of dirt reactivity on handwashing with soap behaviors should be investigated in future studies in other contexts.

High perceived susceptibility was significantly associated with higher handwashing with soap at food- and stool-events among caregivers at the 6-month follow-up. This finding is consistent with previous studies that found perceived susceptibility to be a factor in a person's decision to wash their hands with soap (Contzen et al., 2015; Scott et al., 2007). Previous WASH intervention studies have found that targeting perceived susceptibility in behavior change communication can lower this psychosocial factor because those who adhere to the intervention feel less vulnerable to diarrheal diseases (George et al., 2017b; George et al., 2021a; Inauen and Mosler 2014).

Psychosocial determinants of handwashing with soap found in this study were targeted in the development of the REDUCE Baby WASH

Handwashing with Soap Module. The Handwashing with Soap Module promoted a tippy tap to increase self-efficacy by providing an enabling technology to make handwashing with soap at stool- and food-related events easier for caregivers (Kuhl et al., 2021). A pictorial flipbook explained how to construct tippy taps (a low-cost, locally-made handwashing station) and prepare soapy water (water and detergent powder), a low-cost alternative to bar soap. Perceived susceptibility was targeted by creating stories about how severe diarrhea can be transmitted to children. In the module, the pictorial flipbook targeted dirt reactivity through stating that even hands that appeared to be clean by the eye could still have intestinal worms and germs that can make young children sick with severe diarrhea.

There are several strengths in this study. First, this study investigated psychosocial WASH factors and their association to caregivers stopping a child from mouthing a dirty fomite. This is a potential transmission route that is not often focused on in WASH interventions. Second, this study measured handwashing with soap behaviors using 5-hour structured observations. This approach enabled us to observe behaviors rather than relying on caregivers' reports. Third, we conducted a prospective analysis that measured psychosocial factors at baseline and WASH behaviors at the 6-month follow-up.

This study has some limitations. The 5-hour structured observation could be subject to the Hawthorne effect (Adair 1984). We tried to reduce this bias by not telling caregivers what we were observing, rather than we were there to observe day-to-day activities. In addition, given the long time-gap between the baseline questionnaire and the structured observation, the potential for this study to have substantial Hawthorne effect is low. Second, we were not able to distinguish between food- and stool-related handwashing events in our analysis; these events were combined to any key event to increase statistical power. Third, this analysis focused on psychosocial at the household, individual and habitual levels of IBM-WASH. Future studies should include items that measure contextual and technological factors that also influence WASH behaviors at the interpersonal, community, and structural levels.

5. Conclusion

Our findings supported the development of the REDUCE Baby WASH modules currently being delivered to over 1 million beneficiaries in South Kivu and Tanganyika provinces of DRC. This is the first study published investigating psychosocial determinants of WASH behaviors in rural DRC. This study took a theory-driven and evidence-based approach to identify psychosocial determinants of WASH behaviors, and developed intervention modules to intervene upon the identified determinants. In addition to supporting the development of targeted WASH interventions in rural DRC, these findings highlight a gap in current literature focusing on psychosocial factors that influence WASH behaviors, in particular, caregivers stopping a child from mouthing dirty fomites. Given the growing literature demonstrating that child mouthing of dirty fomites is associated with diarrheal disease, environmental enteropathy, and impaired growth, further studies are needed that investigate the behavioral determinants driving caregiver responses to child mouthing events.

Declaration of competing interest

No authors have a conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijheh.2021.113850>.

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