

USING MOBILE HEALTH MESSAGING TO NUDGE BABYWASH BEHAVIORS

FORMATIVE RESEARCH FINAL REPORT



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ACRONYMS

BabyWASH	Baby Water, Sanitation, and Hygiene Program
CHoBI7	Cholera Hospital-Based Intervention for 7 Days
EE	Environmental Enteropathy
FGD	Focus Group Discussion
GESI	Gender Equality and Social Inclusion
HBC	Hygiene Behavior Change
Icddr,b	International Centre for Diarrhoeal Disease Research, Bangladesh
IBM-WASH	Integrated Behavioral Model for Water, Sanitation, and Hygiene
IVR	Interactive Voice Response
JHSPH	Johns Hopkins Bloomberg School of Public Health
mHealth	Mobile Health
MOHFW	Ministry of Health and Family Welfare
ORS	Oral Rehydration Salts
RANAS	Risks, Attitudes, Norms, Abilities, and Self-Regulation
RCT	Randomized Controlled Trial
WASH	Water, Sanitation, and Hygiene
WASHPaLS	Water, Sanitation, and Hygiene Partnerships for Learning and Sustainability

EXECUTIVE SUMMARY

Children less than five years of age are at greater risk of diarrheal diseases globally. Frequent diarrhea is associated with growth faltering and poor cognitive development, which together accounts for a huge global burden. Multiple risk factors have been identified for diarrheal diseases in children that include poor food hygiene practices, unsafe disposal of child feces, child mouthing of contaminated fomites, and the poor hand hygiene of caregivers of young children. Behavior change communication attempted by delivery of health information through mobile technologies (mHealth) constitutes a low-cost, reflexive, scalable approach to foment behavior change. This USAID research grant sought to answer the overall research question: Can mHealth messaging effectively nudge and sustain improved Baby Water, Sanitation, and Hygiene (BabyWASH) behaviors, forming new hygiene habits for improved infant and young children's health and growth? The goal was to develop a scalable approach to promote safe child feces disposal, improved food hygiene, and reduced childhood mouthing of soil and contaminated fomites.

This research was conducted in urban slums of Dhaka, Bangladesh from July 2018 to March 2020. Participants included caregivers of young children (mothers, fathers, and grandparents) and government stakeholders. We developed three modules in the BabyWASH mHealth program: 1) child feces disposal behaviors, 2) child mouthing behaviors, and 3) food hygiene behaviors. The focus of the formative research conducted under this grant was on the development of intervention content for the BabyWASH mHealth modules and piloting of the developed intervention.¹ The formative research and intervention development process followed the Integrated Behavioral Model for WASH (IBM-WASH) model, as well as System 1 and System 2 drivers of basic habit science and “nudging theory.” Formative research activities included three components: (1) exploratory interviews, (2) intervention development through mHealth workshops, and (3) pilot studies of the BabyWASH mHealth modules. The BabyWASH mHealth program was delivered by mobile and voice messages using the Viamo platform. The developed mHealth modules were tested over the course of four iterative phases of a pilot study and evaluated through a mixed-methods approach that included semi-structured interviews, group discussions, unannounced spot checks, and structured household observations.

Findings from semi-structured interviews and group discussions indicate that caregivers of young children have relatively high awareness of the need for safer food hygiene, child mouthing, and child feces disposal practices, but are limited in their ability to perform these behaviors due to time spent on household chores and restricted access to enabling technology to practice recommended behaviors. The target households received both text and voice messages and sometimes shared these with neighbors. Caregivers also expressed their preference for interpersonal contact (in person visits) to reinforce the delivery of pictorial modules and technology of the mHealth BabyWASH program.

Initial findings indicate that mHealth alone is not sufficient to trigger or sustain changes in BabyWASH behaviors. These BabyWASH behaviors were new and complex behaviors for caregivers, and researchers concluded that intensive, interpersonal visits were required to introduce and negotiate the new practices. Additionally, we also observed that female beneficiaries had lower rates of phone ownership than male beneficiaries and did not always receive program messages. Delivery of the pictorial modules in-person helped us ensure program content was accessible to more program beneficiaries.

¹ We originally planned to carry out a randomized controlled trial (RCT) incorporating the findings of the formative research. After beginning our formative research, we found that more exploratory research was needed to understand these key behaviors. Given this, icddr,b felt it inadvisable to proceed with an RCT, and proposed to WASHPaLS that we instead carry out more extensive exploratory qualitative research and piloting than originally proposed, extending formative activities for the total grant period and eliminating the RCT.

This research presents a theory-driven and evidence-based approach to developing a BabyWASH mHealth program targeting food hygiene, child mouthing, and child feces disposal behaviors in urban Dhaka, Bangladesh. Although the findings of the study are limited to diarrhea patient households in urban Dhaka, and study proceedings were suspended due to the COVID-19 pandemic, this study is the first, to our knowledge, to conduct formative research and intervention development for a BabyWASH mHealth program. The study shows that mHealth can play a role in more comprehensive behavior change approaches to improve infant-related hygiene practices, but not as a stand-alone intervention. Future research is needed to observe if these practices can be sustained over time and to determine the feasibility of scaling this program across Bangladesh, and elsewhere.

I.0 INTRODUCTION

Diarrheal disease continues to be a major cause of mortality among young children globally, causing 500,000 deaths annually (GBD Diarrhoeal Diseases Collaborators, 2017). The first two years of life are a critical window for child health and development; and the water, sanitation, and hygiene (WASH) behaviors of caregivers are important contributors to both during this time (Victoria et al., 2010; Wodnik et al., 2018). Exposure to fecal pathogens due to poor hygiene and water treatment practices in the home is associated with an increased risk of diarrheal diseases and environmental enteropathy (EE) in young children (Wodnik et al., 2018; Esrey, 1996; Saha, 2013; George et al., 2014). EE is a disorder defined by abnormal intestinal morphology, which increases intestinal inflammation and reduces barrier function. This disorder has been associated with impaired growth in susceptible pediatric populations (George et al., 2018; Owino et al., 2016). Previous studies have identified multiple risk factors for diarrheal diseases and EE among young children, including poor food hygiene practices (Agustina et al., 2013; Esrey et al., 1991; Takanashi et al., 2009), unsafe disposal of child feces, child mouthing of contaminated fomites, and poor hand hygiene of caregivers (Esrey, 1996; Saha, 2013; George et al., 2014; Pathela et al., 2006; D'Souza, 1997; Ghosh et al., 1997; Sobel et al., 2004; Burrowes et al., 2017; Morita et al., 2017). It is important for WASH interventions to be tailored to susceptible pediatric populations by recognizing the unique exposure routes to fecal pathogens for young children.

Poor food hygiene practices among caregivers have been associated with diarrhea in young children in multiple settings (Austina et al., 2013; Takanashi et al., 2009). Several interventions to improve food hygiene behaviors in the home have been developed for rural settings (Islam et al., 2013; Gautam et al., 2017), but effective interventions in urban settings are limited. A study conducted in Bangladesh found that 40% of complementary food samples taken from urban and rural homes were contaminated with *E. coli*; and contaminated food was associated with an increased risk of diarrhea among young children (George et al., 2016). Our recent study in rural Bangladesh found that mouthing of contaminated fomites, such as bottles, toys, and wrappers with visible dirt, was observed in more than 60% of children under two years of age, and was associated with EE (Burrowes et al., 2017; Morita et al., 2017). Despite evidence showing an association between childhood mouthing of contaminated fomites and poor child health outcomes (Morita et al., 2017; Perin et al., 2016), there have been no intervention studies published in Asia targeting child mouthing. Finally, sanitation interventions typically focus on construction of improved sanitation facilities and target adult defecation practices (Takanashi et al., 2009; Pathela et al., 2006; D'Souza, 1997). There is minimal attention given to safe disposal of feces from child open defecation events (Hussain et al., 2017; Luby et al., 2018), despite unsafe child feces disposal being common globally and associated with pediatric diarrhea, EE, and impaired child growth (D'Souza, 1997; Ghosh et al., 1997; George et al., 2016).

Community-based behavior change interventions are expensive and difficult to implement in low-resource urban settings (Qadri et al., 2015). The use of mobile technologies for delivery of health information, referred to as mobile health (mHealth), is a promising, low-cost, scalable approach to facilitate behavior change (Zurovac et al., 2011; Cole-Lewis & Kershaw, 2010; Free et al., 2013; Higgs et al., 2014; Gibson et al., 2017). Mobile phone subscriptions have grown enormously worldwide; more than doubling over the last 10 years (Biganzoli et al., 2006). It was estimated in 2017 that there were 85 million unique mobile phone subscribers in Bangladesh, half of the country's population (GSMA, 2018). Bangladesh is an ideal setting for mHealth behavior change programs.

The Cholera Hospital-Based Intervention for 7 Days (CHoBI7). Household members of cholera patients are at a much higher risk than the general population of developing diarrheal diseases during the seven-day period after the cholera patient appears at a health facility (Weil et al., 2009; George, Ahmed et al., 2015; Black et al., 1981). To develop an intervention for this high-risk population, we developed

the CHoBI7 WASH mHealth program (George, Zohura et al., 2019; Thomas et al., 2020). The intervention includes sending voice and text messages to members of the diarrhea patient's household to promote handwashing with soap and water treatment. A recent randomized controlled trial (RCT) of the CHoBI7 WASH mHealth program showed significant improvements in handwashing with soap and stored household drinking water quality, and lower pediatric diarrhea and stunting over the 12-month study period (George, Monira et al., 2019). This was the first RCT of a WASH mHealth program and demonstrates that mHealth is a promising approach to facilitate WASH behavior change. We are currently partnering with the Bangladesh Ministry of Health and Family Welfare (MOHFW) to scale this mHealth intervention program across Bangladesh.

Building on our previous work, the focus of this study was to develop and test the use of the mHealth approach, specifically targeting infant and young child-specific exposure routes: safe child feces disposal, improved food hygiene, and safe child mouthing practices as a follow-on to the CHoBI7 WASH mHealth program. We refer to this intervention as the BabyWASH mHealth program. The MOHFW Director of Disease Control requested that the International Centre for Diarrheal Disease Research, Bangladesh (icddr,b) add these mHealth modules to the CHoBI7 intervention to build evidence on low-cost approaches that could be adopted by the ministry to protect susceptible pediatric populations from infectious diseases. The phone-based reminders of mHealth messages would serve as a reflexive, cue-driven approach to facilitate hygiene behavior change (HBC).

The research was conducted by icddr,b in partnership with the MOHFW Director of Disease Control, and the Johns Hopkins Bloomberg School of Public Health (JHSPH). The research activities align with the overall objective of the Water, Sanitation, and Hygiene Partnerships for Learning and Sustainability (WASHPaLS) grants program to investigate the effectiveness of innovative approaches to improving and sustaining hygiene behaviors, and more specifically to support learning related to the application of habit formation and gender equality and social inclusion (GESI) principles to HBC.

2.0 STUDY METHODS

2.1 STUDY RATIONAL

This research grant sought to address the following research question:

Can mHealth messaging effectively nudge and sustain improved BabyWASH behaviors, forming new hygiene habits for improved infant and young children’s health and growth?

The goal was to develop a scalable approach to promote safe child feces disposal and improved food hygiene, and to reduce childhood mouthing of soil and other contaminated fomites.

This BabyWASH mHealth study used a theory-based approach, building on the original CHoBI7 intervention informed by components of several behavior change models used to target psychosocial factors (e.g., the Theory of Planned Behavior; the Integrated Behavioral Model for Water, Sanitation, and Hygiene [IBM-WASH]; the Health Belief Model; and the Risks, Attitudes, Norms, Abilities, and Self-regulation [RANAS]). By measuring these factors during our recent efficacy trial of CHoBI7, we were able to identify the underlying mechanism of change that resulted in the high handwashing with soap behavior observed among intervention participants. Through this analysis we identified key psychosocial factors of habit formation and sustained behavior change to target in the current intervention.

This study sought to develop BabyWASH mHealth modules using a similar evidence-based, theory-driven approach to target potential mediators of habit formation for safe child feces disposal (defined as disposal of child feces in a toilet), improved food hygiene, and practices to ensure safe child mouthing behaviors. Specific attention was given to the multiple levels of influence that may interact with psychosocial determinants of behavior change. Taking guidance from IBM-WASH (Dreibelbis et al., 2013), we analyzed formative findings to develop modules including messages to help regulate factors that facilitate or impede recommended practices, ranging from habitual to structural/societal-level drivers of WASH outcomes.

By incorporating multi-level, multi-dimensional factors into program messaging, we aimed to address the underlying mechanism of change for promoted BabyWASH behaviors given the context. Mobile messages provide the unique opportunity to target determinants at multiple levels, such as sending messages at specific times of day as nudges to assist with habit formation, and sending messages to male heads of household to encourage WASH practices typically promoted among women only.

With respect to habit science and nudging theory, Neal et al. (2015) draw on the field of psychology, behavioral economics, and cognitive science and assert that behavior is a product of two “brain systems:” System 1 includes automatic, cue-driven factors (e.g., existing habits), whereas System 2 includes rational, motivational factors (e.g., intentions). Behaviors that are performed frequently in the same environment, like many WASH behaviors, are thought to be part of System 1. The authors subsequently outline eight principles that focus on System 1 “tactics” to disrupt existing habits and make small changes to the environment, called “nudges,” that encourage the target behavior:

- 1) Managing physical availability of enabling technology and infrastructure,
- 2) Leveraging context changes to introduce new behaviors,
- 3) Piggybacking on existing cues and behaviors,
- 4) Managing perceived and actual friction to performing a behavior,
- 5) Supporting context-stable repetition,
- 6) Embedding ritualized elements in the behavior change process,
- 7) Leveraging point-of-action reminders and situational cues, and
- 8) Highlighting descriptive and “localized” norms.

In this study, we sought to incorporate both System 1 and System 2 tactics for behavior change into the BabyWASH mHealth modules (Annex I provides examples of behavior change techniques and mobile messages that are informed by System 1 principles).

2.2 STUDY OBJECTIVES

The original objectives of this study were:

Objective 1: Develop and test mHealth modules on safe child feces disposal, improved food hygiene practices, and reduced childhood mouthing of soil and other contaminated fomites.

Objective 2: Evaluate the effectiveness of delivering these three new mHealth modules as part of the CHoBI7 intervention using a RCT design, in terms of (1) increases in safe child feces disposal practices, handwashing with soap at food- and stool-related events, safe food storage, cleanliness of child play spaces, and reduced childhood mouthing of soil and other contaminated fomites (the key behaviors for the new mHealth modules); and (2) reductions in pediatric diarrheal disease prevalence.

Objective 3: Investigate the feasibility of implementing the new CHoBI7 mHealth modules as part of the National Operational Plan for Communicable Disease Control through the identification of barriers to successful implementation and engagement with key government stakeholders.

Objective 4: Disseminate the findings of research activities at the household, health facility, and government levels through workshops, policy briefs, scientific publications, and presentations.

Objectives 2 and 3 were subsequently removed from the study for reasons explained below. The study thus focused on the formative research of Objectives 1 and dissemination of Objective 4.

2.3 STUDY DESIGN

The BabyWASH mHealth program was designed as a follow-on to the CHoBI7 mHealth program. We originally planned to carry out an RCT on the development of BabyWASH mHealth modules targeting improved food hygiene, safe child mouthing, and safe child feces disposal behaviors. With this aim, we conducted formative research to design and develop mHealth modules for our proposed RCT. WASH mobile health programs are a new field of research, and our recent RCT of the CHoBI7 mHealth program was the first WASH mHealth program to be conducted. As such, there is little evidence base on how to effectively deliver mHealth BabyWASH interventions targeting our key behaviors to facilitate WASH behavior change.

After beginning our formative research, we found that exploratory research to understand these key behaviors needed to be more extensive than originally planned, and during piloting we found that caregivers faced challenges performing these key behaviors. Given this, icddr,b felt it inadvisable to proceed with an RCT, and proposed to USAID/WASHPaLS that we instead carry out more extensive exploratory qualitative research and piloting than originally proposed, extending formative activities for the total grant period and eliminating the RCT.

Thus, of the original study design that comprised three parts (formative research, RCT, and dissemination) roughly corresponding to the research objectives, only Part 1 (plus some dissemination; see Annex 4) was completed, consisting of 1) semi-structured interviews and group discussions (Component 1); 2) mHealth workshops (Component 2); and 3) pilot studies of the developed intervention (Component 3, consisting initially of three phases). To address the need for more extensive formative research, a fourth phase was added to the piloting activities that included 120 additional households, as summarized in Table I.

Table 1. Summary of Pilot Study Phases

PILOT PHASE	MODULES	INTERVENTION DELIVERY STRATEGIES	PARTICIPANTS
Phase 1 (50 HHs)	Food hygiene Safe child feces disposal Child mouthing	mHealth messages	CHoBI7 Study Participants Infants <5 years of age
Phase 2 (20 HHs)	Food hygiene Safe child feces disposal Child mouthing	mHealth messages Two Home Visits	CHoBI7 Study Participants Infants <2 years of age
Phase 3 (32 HHs)	Food hygiene Safe child feces disposal Child mouthing	Hospital visit mHealth messages Two Home Visits	Enrolled New Study Participants Infants <2 years of age
Phase 4 (120 HHs)	Food hygiene Safe child feces disposal Child mouthing	Hospital visit mHealth messages Two Home Visits	Enrolled New Study Participants Infants <2 years of age

This report focuses on findings of the expanded pilot testing of 120 HHs (i.e., Phase 4), though we will reference findings from previous phases as needed to complement and/or contextualize findings to draw overall conclusions from the study. Findings from the semi-structured interviews (Component 1) and the mHealth workshops (Component 2) are presented in Annex 2. Findings from Pilot Phases 1-3 (Component 3) are provided in Annex 3 and summarized in Table 2. Table 2 also presents how findings from one pilot phase were incorporated in the design of subsequent phases, including from Phase 3 to Phase 4. A significant change from Phase 3 to Phase 4 was that the number of key behaviors was reduced to three per module to help caregivers remember what was being promoted (see Table 3).

Table 2. Key Findings from Pilot Phases 1-3

ACTIVITY	KEY FINDINGS/ CHALLENGES	INTERVENTION REVISIONS RECOMMENDED FOR NEXT PHASE
<p>Phase 1 (50 Households)</p> <ul style="list-style-type: none"> ▪ Delivery of BabyWASH module to standard message group and CHoBI7 mHealth program group households from previous RCT (through mHealth, no home visit) ▪ Biweekly voice and text messages were sent to households for 3 months (no home visits) ▪ Targeted households with children less than 5 years of age 	<ul style="list-style-type: none"> ▪ Some pilot participants reported that the mobile messages were not sufficient for them to understand the key behaviors promoted, and that in-person visits were needed. ▪ Child mouthing messages were less relevant for children 2 to 5 years old because the behavior decreased. ▪ Standard message group households had more challenges with the promoted behaviors on handwashing with soap compared to CHoBI7 mHealth group households. ▪ Male household members did not always share mHealth messages with female caregivers. ▪ Laboratory findings showed high fecal contamination on balls and plastic toys young 	<ul style="list-style-type: none"> ▪ A pictorial module and cue cards were added for each key behavior. Provided in-person guidance on how to receive text messages and respond to IVR quiz questions before mobile messages were sent to households. ▪ Interventions included only households with a child under 2 years of age. ▪ All mobile messages were tailored to target System 1 (relatively automatic, cue-driven drivers of behavior change) to ensure both automatic and cue-driven factors and relatively conscious and motivational factors were being targeted. ▪ Only households in the CHoBI7 mHealth group of the previous RCT were included. ▪ The length of text messages was reduced to less than 160 characters. ▪ Program households were sent voice messages at 5 PM. ▪ Based on laboratory findings, cleaning child toys with detergent and water daily was added to the child mouthing

ACTIVITY	KEY FINDINGS/ CHALLENGES	INTERVENTION REVISIONS RECOMMENDED FOR NEXT PHASE
	<p>children put in their mouth, and in rice given to young children.</p>	<p>module, and a section was added to the food hygiene module explaining the importance of reheating and safely storing rice given to young children.</p>
<p>Phase 2 (20 Households)</p> <ul style="list-style-type: none"> ▪ Delivery of BabyWASH module to only CHoBI7 mHealth program households from previous RCT ▪ Health promoters delivered pictorial modules in two home visits ▪ Biweekly voice and text messages were sent to households for 1 month (no home visits) ▪ Targeted households with children less than 2 years of age 	<ul style="list-style-type: none"> ▪ Male household members were not always engaged in key behaviors. ▪ Some beneficiaries were confused about how existing practices related to the promoted key behaviors presented in the pictorial module. ▪ Some households reported that they did not use soapy water because young children played with it. ▪ Some photos in the pictorial modules were not clear to pilot participants. 	<ul style="list-style-type: none"> ▪ Households were encouraged during the recruitment process to provide the numbers of the primary caregiver in the household. ▪ A slide was added to the pictorial module encouraging sharing of mobile messages with other household members (including children). ▪ A slide was added encouraging men to engage in key WASH behaviors. ▪ All captions under the photos in the pictorial module were removed to make the pictorial module delivery more interactive, and to avoid discouraging those that could not read the captions. ▪ Photos that were reported to be unclear by beneficiaries were retaken and tested in subsequent pilot health facilities and the home to introduce beneficiary households to the sender of program messages and to teach them how to respond to IVR quiz messages.
<p>Phase 3 (32 Households)</p> <ul style="list-style-type: none"> ▪ Delivery of BabyWASH module to newly recruited diarrhea patient households ▪ Health promoters delivered pictorial modules during the health facility visits for treatment of diarrhea and two home visits during the seven-day high-risk period after the diarrhea patient presented at the health facility ▪ Biweekly voice and text messages were sent to households for 1 month (no home visits) ▪ Targeted households with children less than 2 years of age 	<ul style="list-style-type: none"> ▪ Participants requested a more detailed introduction on how to respond to IVR quiz messages. ▪ Pictorial modules allowed participants to understand program messages more easily. ▪ Caregivers had difficulty safely disposing of child feces and reheating leftover food. ▪ Caregivers had difficulty remembering all the key behaviors promoted in each module. 	<ul style="list-style-type: none"> ▪ The number of key behaviors was reduced to three per module to help caregivers remember what was promoted. ▪ Modules were revised to target barriers and facilitators identified for completely covering leftover food, and disposing of child feces safely in Phase 3, after finding low uptake of these behaviors in the quantitative pilot assessment. ▪ Instructions were added on timing and duration of mHealth message delivery in the pictorial module delivered during health facility and home visits. ▪ A recording of Dr. Chobi's IVR quiz message was played in the health facility and in the home to introduce beneficiary households to the sender of program messages and to teach them how to respond to IVR quiz messages.

Table 3. Targeted Behaviors for Each Module

PHASE	BEHAVIOR		
	INFANT FECES DISPOSAL	CHILD MOUTHING	FOOD HYGIENE
Phase 1	<ol style="list-style-type: none"> 1. Dispose of child feces in the toilet. 2. Defecate on raxine if there is no child potty or too young. 3. Clean child first after defecating, then clean the feces. 4. Safely dispose of child diapers and soiled clothes. 5. Clean and dispose of child feces. 6. Clean child's potty after use. 	<ol style="list-style-type: none"> 1. Prevent child from putting dirty objects in mouth. 2. Wash child's hands when they are muddy or dirty. 3. Sweep and clean child's play space daily. 4. Provide child with a raxine or clean cloth to play on. 5. Wash child's toys with soap and water. 6. Use a designated space (bin) to dispose waste. 7. Watch child while playing in the roadside. 8. Men should watch their children. 	<ol style="list-style-type: none"> 1. Reheat leftover/stale food. 2. Store cooked food properly with cover. 3. Wash raw foods before eating. 4. Provide clean cloth to child to sit on while eating to prevent taking dropped food from the floor. 5. Wash hands with soap/soapy water during food preparation. 6. Avoid eating street food.
Phase 2	'no changes'	'no changes'	'no changes'
Phase 3	'no changes'	'no changes'	'no changes'
Phase 4	<p>FINAL SET</p> <ol style="list-style-type: none"> 1. Dispose of child's feces in the toilet. 2. Safely dispose of piece of used cloth (soiled cloth) to pick up child's feces. 3. Wash hands with soap or soapy water after coming into contact with feces (After defecation, after cleaning child's anus, and after cleaning child's feces). 	<p>FINAL SET</p> <ol style="list-style-type: none"> 1. Have child sit on a mat/raxine/clean cloth when eating. 2. Stop children from putting dirty things in their mouth. 3. Clean child's toys and other objects they play with frequently. 	<p>FINAL SET</p> <ol style="list-style-type: none"> 1. Completely cover leftover food. 2. Reheat leftover food thoroughly. 3. Wash hands thoroughly with soap before food preparation and before feeding the child.

As noted, the BabyWASH mHealth program was based on the initial CHoBI7 mHealth program design. Elements of the intervention were similar to CHoBI7 and included 1) delivery of mobile and voice messages using the Viamo platform; 2) inclusion of interactive voice response (IVR) messages as “quizzes” that participants could respond to; 3) initial program delivery through an in-person visit to deliver a pictorial module (added to Phases 2, 3, and 4 following findings from Phase 1); and 4) involvement of two study “characters” for intervention delivery, Dr. Chobi and Aklima.



Dr. Chobi Apa represents a friendly woman physician, communicating directly with households through voice and text messaging.

The two study characters were developed for the CHoBI7 mHealth program (George, Zuhura et al., 2019). Dr. Chobi is a doctor at a hospital who calls and texts diarrhea patient households to share information and reminders on recommended WASH behaviors to keep children and household members healthy. She is sometimes called “Dr. Chobi Apa,” meaning “Sister Dr. Chobi.” Aklima is a woman who brought her child to a health facility for diarrhea treatment and learned WASH behaviors from Dr. Chobi. There was no fee to households for sending or receiving mHealth messages. These costs were borne by the program (biweekly mobile messaging for one-year costs US\$2 per household using the Viamo platform).

In Phase 4 of the pilot, we included 120 newly recruited diarrhea patient households at the Dhaka icddr,b hospital from October to December 2019. There were 90 households (30

each targeting the three modules: food hygiene, child mouthing, and child feces disposal) that received the BabyWASH mHealth program messaging and in-person modules, and 30 households that received the standard oral rehydration salts (ORS) message (control).² A pictorial BabyWASH module was delivered to program households by a trained health promoter in the health facility to reinforce the mHealth message, in addition to two home visits during the seven-day high-risk period (Day 2 and Day 5) after the diarrhea patient presented themselves at the hospital. These households also received a handwashing station and cue cards on key behaviors, and biweekly voice and text messages focusing on System 1 drivers of behavioral change for up to three months. As with Phases 2 and 3, Phase 4 targeted households with a child under two years of age.

To evaluate the effectiveness of the mHealth messaging and in-person BabyWASH modules, semi-structured interviews (n=23) and focus group discussions (FGDs) (n=5) were conducted with pilot study participants (caregivers of young children) to explore barriers and facilitators to performing the recommended behaviors and to obtain feedback on program content and delivery. FGDs had between 8 to 15 participants and ranged in duration from 1.5 to 3 hours. FGDs were facilitated by members of the research team and took place at the icddr,b project office.

To assess household conditions, unannounced spot checks were conducted in pilot households at baseline and then subsequently after seven days, one month, and at three months to check for behaviors and enabling technologies related to their study group. To observe food hygiene, child feces disposal, and child mouthing behaviors, five-hour structured observation was conducted in pilot households one and three months after enrollment.

However, due to the COVID-19 pandemic and ensuing government restrictions on travel and gatherings, we were unable to complete some of our remaining field visits and related activities. Spot checks and structured observations were not carried out in eight households (three households enrolled in the food hygiene group; two in the child mouthing group; two from the safe child feces disposal group; and one from the standard message/control group). Thus, in consultation with the USAID/WASHPaLS team, the field plan was modified, and analyses completed with the data available.

Sample sizes for the pilot were small and only used to assess trends, not statistical significance. Stata 13 was used to calculate the percentage of the hygiene behaviors for the different phases.

² The original CHoBI7 RCT study design had three study arms: one arm receiving the in-person home visits along with the original in-hospital session and mHealth messages; a second arm receiving only the hospital session followed by mHealth messaging; and a control arm receiving standard ORS messaging.

2.4 STUDY SETTINGS AND PARTICIPATION

This research was conducted in urban Dhaka, Bangladesh from July 2018 to March 2020. Participants included caregivers of young children (mothers, fathers, and grandparents) mostly in slum areas, and government stakeholders. Caregivers of children under five years of age were our initial focus, because children in this age group are considered at risk for enteric disease due to fecal-oral transmission of pathogens along our target routes of exposure: food, fomites, and feces. We later chose to focus on caregivers of children under two years of age, based on preliminary findings that our BabyWASH behavioral recommendations were more relevant for this age group. Therefore, all reporting on Phase 4 research includes caregivers of children under two years of age.

2.5 DATA HANDLING AND ANALYSIS

We conducted the semi-structured interviews in Bangla and recorded and transcribed them verbatim. Exploratory interviews were followed by debriefs and a discussion of findings among the research team to help guide subsequent interviews. FGDs were recorded, and detailed summaries compiled based on field notes and audio recordings. An in-depth, manual analysis of all transcriptions and summaries followed, organized by IBM-WASH factor block and by module topic. This organizational structure facilitated the selection of determinants to target in our intervention program. Throughout the formative research process, emergent findings were discussed by the study team to identify salient themes related to the program's target behaviors. Additional target behaviors were developed as findings emerged.

2.6 ETHICAL APPROVAL

This study was approved by the icddr,b and JHSPH institutional review board ethical review committee. All study participants provided written informed consent.

3.0 RESULTS OF PHASE 4

The major findings from the semi-structured interviews, FGDs, as well as quantitative results from the Phase 4 spot checks are presented here, followed by preferences and recommendations provided by pilot participant households.

3.1 KEY QUALITATIVE FINDINGS

3.1.1 Food hygiene behaviors

Mothers, the primary caregivers for children, are mostly responsible for the preparation and cooking of foods and for looking after their children's behavior and health. However, in some cases, these responsibilities were delegated to the child's grandmother or attendant (siblings or aunts) if the mother was busy with work outside of the home. Food preparation (e.g., cutting vegetables and meat before cooking) was generally performed inside the home (typically households in slum areas of Dhaka reside in a single room) followed by cooking on a stove in a communal kitchen in a compound (where five to six households live).

Food safety: In this phase we found that the knowledge about food safety, like covering foods, reheating leftover food, and keeping food in the refrigerator has been increased:

Apa (Sister Dr. Chobi) has told about food safety that, we are cooking food, after cooking and after eating.... we should keep the food in fridge or if we keep it outside then we should keep it covered.

Dr. Chobi Apa reinforced household habits regarding food safety. It is common practice to reheat food in the morning and evening as households tend to cook the main meal in the evening:

Yes, it's our habit... normally I warm-up refrigerated cold food before she (Dr. Chobi) told me ...the food we keep outside, we warm this in morning and then we eatand in lunch we cook food and eat warm and also at night we warm it and then eat....

Food preparation: Behavior change communication on food hygiene encouraged caregivers to prepare meals daily and feed the child either freshly cooked food or to reheat the previously made food before serving. Caregivers preferred to give children only fresh food. The leftover food from dinner that is eaten the next morning is called "bashi khabar." Bashi khabar, if not rotten, is usually reheated before eating, rotten bashi khabar is thrown away. Most caregivers reported preparing food for children three times per day, and two times a day for adults. They also understood the safe drinking water practices like drinking boiled water to avoid being infected by disease agents. Participants believe that this food hygiene practice can help them to keep their children healthy:

Yes, Apa (sister Dr. Chobi), it is like Apa has told us to make food for each time rather than eating bashi khabar (stale food), it is also good, otherwise Apa wouldn't pressure us, I mean she told the way we are benefited as like when we have, we should have it by warming, but we should not take cold food So, Apa didn't tell any wrong things here. Yes, Apa has told to eat cold food by warming it, not to eat cold food, not to make children sick, and not to make yourself sick.

In areas without sufficient gas supplies, households eat food without reheating. One caregiver mentioned that they could not reheat food before eating due to the unavailability of gas:

So, what do we do; for unavailability of gas; we have to eat food that was cooked yesterday. There is a problem with gas supply, isn't it! Gas was not available so far. We used to cook food at night in winter around 12 to 1 am, and have to eat that food without heating for the whole day. Could not even offer some hot water for children to take bath, it is a problem. Gas is not available.

Foods from the outside: Fruit and vegetable items were typically soaked in a bowl of water, then the water was poured out of the bowl and these items were considered “safe” for consumption. Participants stated that having food from the outside or any street foods or smoking by any of their family members could make their child sick:

Yes, like as always keeping the foods covered, reheat the stale food before eating, if rice becomes stale then reheat before eating; these things...Again wash fruits after bringing those from market and then eat.

Few days ago she (Dr. Chobi Sister) said that, it would be good if brothers (males) don't eat foods like shingara, puri (street snacks items) from outside of home. If they eat those, then their children can get sick (as well as them). Also, there are many brothers who used to smoke cigarette, that is not fair either.

Sharing knowledge with neighbors: Mothers with “new knowledge” about food hygiene reported they encourage their neighbors to follow the same food hygiene-related behaviors for their wellbeing:

I have shared with them that you have children so, you have to reheat the bashi khabar (stale food), cover food with a lid, if you go to the toilet-bathroom then wash your hands with soap, wash your child and so on....for mothers with children.

Yes. I shared with my neighbor and asked to feed children after washing hands and always keep children clean. Don't allow children to touch dirty things. Because that can go into their stomach.

Father's involvement: Fathers' help during the food preparation was expected by the primary caregivers. Caregivers mentioned that they need help from the fathers to look after the children so that they could be able to manage household chores. Taking care of their child as recommended was an extra burden but the message on father's involvement helped them to follow:

if babu's (baby) father does some work when the baby is with the mother, it will help mother at work, keeping an eye on the baby.

Suppose...I am doing some household activities, then he (husband) can feed the child after washing hands properly; again the child is handling some dirt while I am cooking, he can stop the child from handling dirt, and wash child's hands with soap; (he can do) something like this.

But a father during the interview with his wife mentioned that he never heard about this though the researcher tried to get the exact opinion by probing:

(-)...they have never talked about taking care, how can we do this, what.....I can't say this.

3.1.2 Child mouthing behaviors

Children like to play in the compound area either in the shared corridor (common space) or outside of the compound near the roadside. Mothers, the primary caregivers, are more aware than before of the importance of children not putting dirty items in their mouths as they now have knowledge about child mouthing behaviors.

Clean environment: One respondent mentioned that she always kept her child clean and did not allow the children to touch dirty things and put them in their mouth. A clean environment was important to save her children from getting diseases. The caregiver stated that it was important to be aware of child mouthing behaviors, and that it was important to supervise children closely when they play, to wash their hands if they get dirty, and to keep the household, child play spaces, and toys clean:

Toys and clothes which the baby plays with and on, need to be clean. Need to keep baby away from dirt of floor, need to keep the baby neat and clean and away from dirt ... so that the baby cannot put into its mouth.... I need to wash (my) hands before eating... it feels good to me now..., Ma-Sha- Allah (God has willed it) my son is good.

Playground and toys: During play activities young children were often with other children in the neighborhood, and sometimes elder siblings or adult caregivers were present with them. Caregivers preferred children play inside the household with toys rather than be outside and getting dirty:

Yes, it (playground) can be kept clean. Whatever work I do will be good, to keep babies away from dirt, not to let them play on dirt, have them play on clean place, not to let them play on floor, if they want child to play with toys on floor then they have to clean the floor first

Better to give toys on a clean cloth, then there will be no problem if not washed... Let them play in a good place, keep away from dirt.

Sharing child mouthing messages with neighbors: Neighbors who have young children like the study participants also practiced the same behavior for keeping their child healthy. Their interest related to child mouthing behaviors; namely, to keep the playground clean, or to keep toys clean, not to let the child put anything into its mouth and so on have increased:

Actually, they asked us what this is, I have told them everything.... Yes, Ma-Sha-Allah (God has willed it) my neighbors do.... I told them many times, they told me that they have a little child, I told them to do, they do as well.

Father's involvement: Father's involvement in the household activities is expected by the mothers to take care of their baby. Mothers need a supporting hand to ensure that their child is not putting any dirt or anything else into its mouth, which could be harmful for the baby's health:

3.1.3 Child feces disposal behaviors

Many caregivers were often busy with household tasks and said they did not have time to dispose of child feces right away. Infants often defecated on bed covers, rags, or on a raxine (plastic sheet); these items were sometimes kept uncovered in a bowl overnight to be washed the next morning. Caregivers mostly used disposable diapers for infants. Some caregivers reported that households in their neighborhood threw these diapers in an open place where children were sometimes observed playing with them. Many caregivers used old clothes to remove child feces and put this into a plastic bag or dustbin. Some caregivers disposed of child feces in a drain, ditch, or garbage pile. Toilets were not always cleaned after defecation events because caregivers were often busy with other household chores. Some caregivers cleaned toilets with water only and others used detergent powder or liquid soap. Some caregivers mentioned that if toilets were washed with water alone, germs could still be present. Most caregivers cleaned their child's feces and the place of defecation first, before cleaning up their child after a defecation event. Caregivers reported this was because they felt it would be disgusting if someone came and saw the feces in their home.

Disposing of feces in the toilet: Respondents can tell us about the key message of disposing of child feces in the toilet. Participants emphasized the early child habit formation in this regard:

It feels good when child defecates sitting on the commode. If child defecates here and there, feces should be disposed in the toilet by using tissue. And, if using cloth then it should be wrapped in polythene and put into waste bin. You have to wash your hands well (and then she demonstrated handwashing).

Washing hands with soap after cleaning child feces or anus: Study participants also mentioned that both mother and children need to wash hands with soapy water after disposing of the child feces safely in the toilet or after cleaning the child's anus:

Like, if a child passes feces, child's mother and child...if a child defecates on the bed or elsewhere, defecate outside, just dispose of the feces immediately... In the toilet, if a child defecates then that feces need to be disposed of in the toilet immediately.... A child and the mother need to wash their hands with soap or soapy water properly after disposing the feces (child's crying sound) in the toilet.

Disgust at a soiled environment: Some caregivers described how disgusting it is when a child defecates all around the household and that is why they need to clean that place as well as their own for their wellbeing. Another participant mentioned that they need to use locally made plastic scoop for disposing the child feces and keeping the environment clean. Participants are also aware of the flies, especially how they could contaminate food and water by sitting on the feces if it is not cleaned immediately after defecation. Other caregivers mentioned that if a child defecated around the household, flies could sit on these feces and spread diarrhea:

How my child can stay healthy if he defecates in the courtyard; need to buy a belcha (plastic scoop) by 40 Bangladeshi taka for disposing that dirt (feces) of immediately.

.. if a child plays in any place of the courtyard, and s/he defecates over there then we need to dispose of that feces immediately, even we need to clean that place so that no flies can sit there. If a fly sits on food, it can be spoiled immediately like the drinking water or spoiled food. If a child plays...then disease might occur as germs on hands could go into mouth.

Potty cleaning: Mothers expressed they found it difficult for a working mother to clean the potty in a timely way after defecation. The attendant of a child, if the mother is busy, is very reluctant to do this job. They realized that this practice is very helpful for keeping their child healthy though they are not doing it regularly:

No, if I stay home I can, but I don't know what my daughter does.... Yes, I go for work ... When I stay home, I clean it perfectly. No, I don't face any problem it is good ... When I go.... my daughter keeps him, it is a problem, but I do it well.

Using bin: One caregiver mentioned that child feces can be disposed in the waste bin by using a polythene bag so that animals cannot touch the feces to spread diseases:

If you don't want to throw into toilet, then it's okay. Suppose the child is young, then the feces remain soft and tissue can be used for disposing that. And (—) if defecates inside the room or other places, then can use something to pick that...and wrap that in a polythene and then put in a garbage bin. The garbage can then be thrown into the dustbin, so that dogs cannot access that (feces)... and cats cannot create problem. Some people do not know these (-).. have to inform them.

Sharing of child feces disposal mHealth messages with neighbors: Participants like to share their knowledge among the neighbors, but they cannot force them to follow. One participant said that neighbors did not take her advice easily. They ignored her and thought that they knew better than her how to take care of their child:

They followed some, many of them stay healthy, I share it with everyone. I told them, I told them that... I told them that you need to wash your hands just after coming out from toilet, even when your child passes feces in the bed then use a piece of cloth (soiled cloth) toAnd if s/he defecates in the potty then dispose it off immediately in the toilet. Yes, few of them have (one or two) listened...

Father's involvement: Fathers view cleaning of child's anus of feces as burdensome. Yet, if fathers were more involved in household work, it would help the mothers to care for their child:

Fathers don't do (clean anus or feces) of children, mothers always do, and fathers never do.

He goes outside at 7 o'clock, sometimes he comes at 10 or 11 o'clock at night, how will he help us?

3.1.4 Handwashing before feeding and eating

Handwashing is an integral behavior to the three modules. Caregivers reported washing their hands with soap regularly to keep their child healthy and were able to recite the recommended times for handwashing: washing hands with soapy water before eating and feeding a child, after using toilet, after

cleaning child's anus or feces, and before preparing foods. Handwashing was reported to be practiced by all family members to keep themselves healthy:

It (handwashing practice) is easy. Because it is right for our health, it will be better. We will stay healthy all time, will be protected from germs, ...It felt hard earlier. I needed more time before, now I have to do for my child, for myself, for my family. So, it has good benefits and easy to do the work.

Respondents were able to report key messages like washing hands before feeding children can keep child from getting diarrhea. Many respondents reported that handwashing with soap became a habit. Participants reported they liked to wash their hands with soap or soapy water before eating and feeding their child along with other food hygiene-related behaviors:

You asked there, wash hands always before feeding children. Children will not get diarrhea or the chance will be less if you wash hands before feeding them. If you have left over food, reheat the food in the morning before feeding your children. Diarrhea might happen from rice also and you told this too.

Yes, as Apa told to feed children after washing hands; whenever you touch a child, touch after washing hands, doing a work after that involves you to wash your hands, and then touch your child. So, she has told about good.

First time it feels bad that I have to wash hands many times by running, but then, after some days it became a habit. Now it's like if I touch anything then I feel like washing my hands. Yes, the habit of washing hands, I think everybody should do it.

I think it (handwashing) is easy because, she told this so that we remain free from disease and can remain healthy. That's why I think it is easy.

Many respondents reported that handwashing with soap became a habit; and mentioned mHealth messages help people to recall the hygiene-related behaviors and make these their habits:

First time it feels bad that I have to wash my hands many times in rush, but after some days it became my habit

3.1.5 Sharing of all CHoBI7 BabyWASH mHealth messages within the household

Participants reported sharing mobile messages with other household members, especially husbands with their wives. They recommended sharing these messages with neighbors as well. Neighbors and other family members' knowledge were likely increased by sharing of the key messages of Dr. Chobi Apa of Cholera Hospital (icddr,b); children will not get diarrhea by staying clean, learnt many things. I told them and showed them the documents. Wives would remind husbands about receiving phone calls from Dr. Chobi Apa:

Yes, I like to share the messages with my mother-in-law. When I go to my father's house, I share those messages with them as well. I tell them that many people came to our house from Dr. Chobi Apa of Cholera Hospital (icddr,b); children will not get diarrhea by staying clean, learnt many things. I told them and showed them the documents.

Yes, I have discussed, even he (husband) also have informed me about the messages that he received after his returning. But he can't read, but I can read. Yes, I read for my husband.

He didn't say anything rather I also told him that...if the phone call comes to you please receive that and talk for a minute. She (Dr. Chobi) will talk for 1-minute no need to answer... so, you don't have any problem. Yes, he did, he always received. His opinion is as like as mine because of our child, his opinion is that we need to keep our child and family healthy so that we will not face any problem.

3.2 PARTICIPANT RECOMMENDATIONS FOR MHEALTH MESSAGING

Participants recommended that program mobile messages be sent to both husbands and wives. Some female caregivers did not want to share their contact number during recruitment because of concerns

that their husbands may be suspicious of whom they were talking to. Most participants reported wanting to receive program mobile messages between 4 to 8 pm. They preferred this time because this was when most household members, including husbands, were available in their home:

Fathers could not always get time to read or receive phone calls at work:

He could not read most of the time, because he remains busy at work...He used to show me sometimes after returning back to home.

Female caregivers reported lower phone ownership than male household members. Some primary caregivers reported that mobile messages were received by their husbands, who shared it with their wives, which is praiseworthy. One female participant did not feel comfortable with keeping a mobile phone with her, as she felt ashamed:

The messages we got from his father's (Babur Abbu) mobile No, I don't have mobile ... When he was home sometimes, I was also at home that day, and I could see the message has come or he sometimes... -

Participants thought three months was enough to develop the hygiene-related behaviors, but some participants wanted to receive messages for more than a year for their health:

You can give as long as you want. And I can hear...Yes. You can give it as long as your wish. I'll listen.

Attempts of failed calls helped the participants get the message from Dr. Chobi Apa:

If I missed the phone call then, I kept my phone near... with me and when the phone call came to me again, then I received.

Yes, if I missed to receive the first phone call then it came three-four times more. I received after three or four times, I received whenever it came to me.

A few comments noted that hygiene issues are important to all; that economic status did not matter. The environment should be kept neat and clean for better health:

To make it better and more developed, one can learn from another that way if everyone remains alert can stay well. People cannot be recognized as poor only by observing the environment; If you can stay properly, can keep everything good, in care; then it will be good, nice. (—). Here nothing about the comparison between rich and poor; cleanliness is cleanliness for everywhere.....

3.3 KEY QUANTITATIVE FINDINGS

Quantitative data for some of the targeted behaviors for each of the modules (Table 3) were gathered through household observations and unannounced spot checks for participants of the four phases. A five-hour structured observation was conducted in pilot households. Unannounced spot checks were conducted before structured observation visits in all groups, including the standard message/control group. The following present quantitative results from the four phases.

3.3.1 Caregiver safe disposal of child feces during structured observation

One of the promoted behaviors (see Table 3) in the BabyWASH Safe Child Feces Disposal Module was for caregivers to dispose of child feces in the toilet. During the five-hour structured observation, 50% (2/4) of Phase 2 caregivers, 43% (3/7) of Phase 3 caregivers, and 70% (7/10) of Phase 4 caregivers disposed of child feces in the toilet. This is compared to 42% (5/12) in the standard message group during the one-month follow-up. At the three-month follow-up, 73% (11/15) of Phase 4 caregivers disposed of child feces in the toilet (Figure 1).

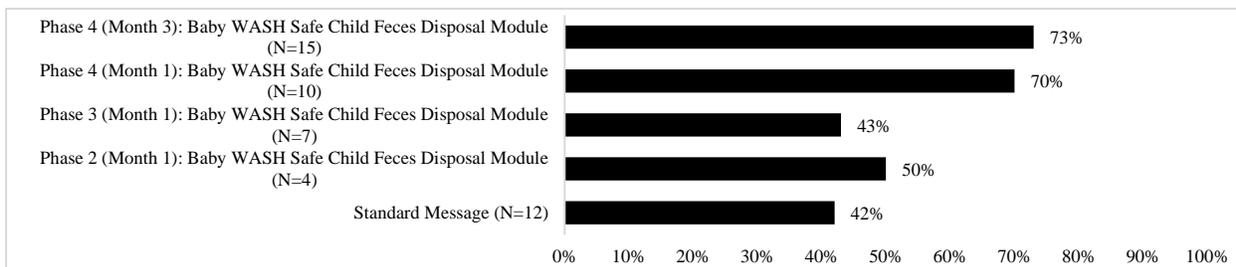


Figure 1. Caregiver safe disposal of child feces during 5-hour structured observation

3.3.2 Caregiver handwashing with soap after cleaning a child’s feces during structured observation

One of the promoted behaviors in the BabyWASH Safe Child Feces Disposal Module was handwashing with soap after cleaning a child’s feces. During the five-hour structured observation, 33% (2/6) of Phase 2 caregivers, 67% (4/6) of Phase 3 caregivers, and 100% (8/8) of Phase 4 caregivers were observed washing their hands with soap after cleaning a child’s feces compared to 56% (5/9) of caregivers in the standard message group at the one-month follow-up. At the three-month follow-up, 70% (7/10) of Phase 4 caregivers were observed washing their hands with soap after cleaning a child’s feces.

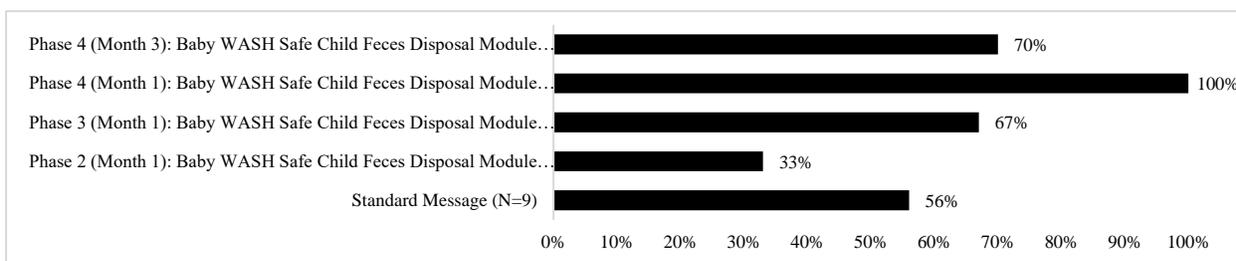


Figure 2. Caregiver handwashing with soap after cleaning child feces during an observation

3.3.3 Handwashing with soap before preparing food during structured observation

One of the promoted behaviors in the BabyWASH Food Hygiene Module was to wash hands with soap before food preparation. During the five-hour structured observation, 0% (0/4) of Phase 2 participants, 0% (0/18) of Phase 3 participants, and 10% (9/87) of Phase 4 participants were observed washing their hands with soap before food preparation events, compared to 3% (2/70) of participants in the standard group during the one-month follow-up. At the three-month follow-up, 10% (8/80) of Phase 4 participants were observed washing their hands with soap before food preparation events.

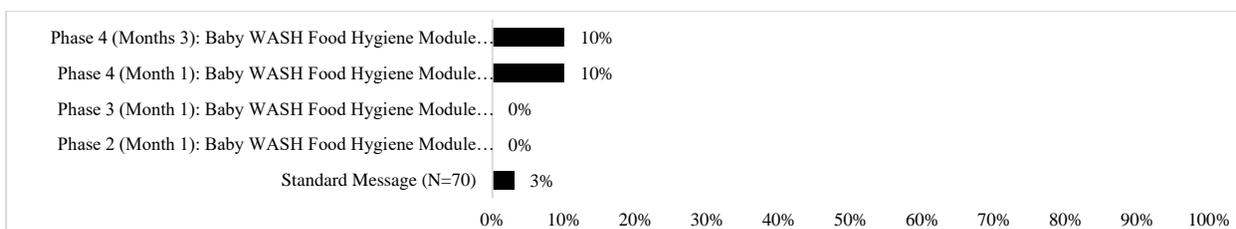


Figure 3. Handwashing with Soap before Preparing Food during Structured Observation

3.3.4 Safe food storage during structured observation

One of the promoted behaviors in the BabyWASH Food Hygiene Module was to cover all cooked foods in the household. During the five-hour structured observation, 83% (19/23) of food storage events for Phase 2 households, 57% (17/30) of food storage events in Phase 3 households, and 65% (129/198) of food storage events for Phase 4 households involved covering leftover food, compared to 48% (72/151)

in the standard message group at the one-month follow-up. At the three-month follow-up, 65% (122/189) of food storage events for Phase 4 households involved covering leftover food.

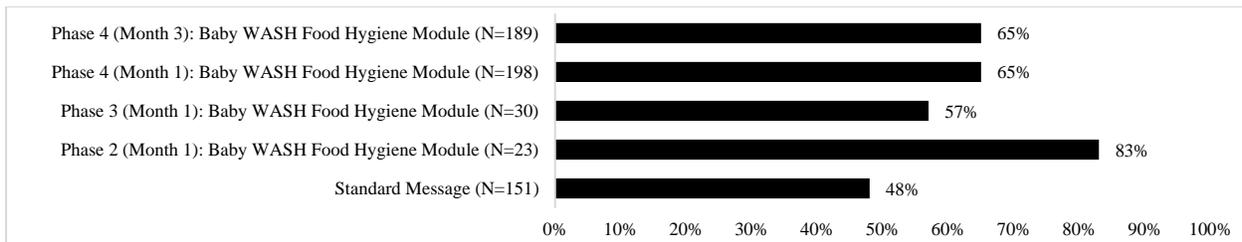


Figure 4. Food covered during food storage events during structured observation

3.3.5 Child fed on a mat during structured observation

One behavior promoted in the BabyWASH Food Hygiene Module was having a child sit on a mat while being fed to prevent food from falling on the ground then being eaten. This behavior was observed during structured observation. During the five-hour structured observation, 18% (2/11) of child feeding events in Phase 2 households, 25% (1/4) of child feeding events in Phase 3 households, and 38% (11/32) of child feeding events in Phase 4 households had the child sitting on a mat, compared to 14% (6/42) in the standard message group at the one-month follow-up. At the three-month follow-up, 42% (22/53) of child feeding events in Phase 4 households had the child sitting on a mat.

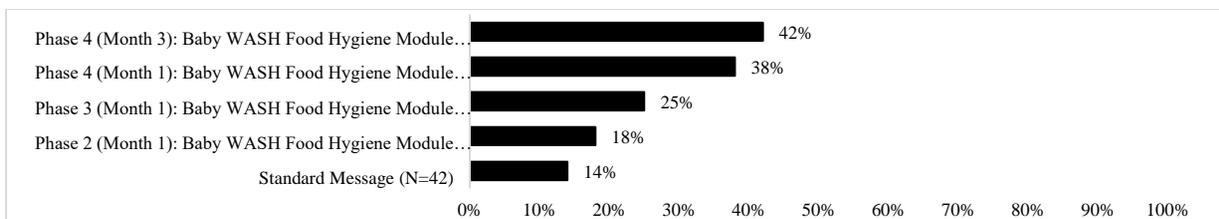


Figure 5. Children fed on a mat during structured observation

3.3.6 Child on a plastic or woven mat on the floor during unannounced spot checks

One of the promoted behaviors in the BabyWASH Child Mouthing Module was to have children sit on a plastic or woven mat when eating and playing to reduce contact with contaminated surfaces in their play spaces. During unannounced spot check visits, 40% (2/5) of Phase 2 households, 67% (6/9) of Phase 3 households, and 33% (9/27) of Phase 4 households had a child sitting on a plastic or woven mat on the floor compared to 47% (16/34) in standard message group at the one-month follow-up. At the three-month follow-up, 33% (9/27) of Phase 4 households had a child sitting on a plastic or woven mat on the floor.

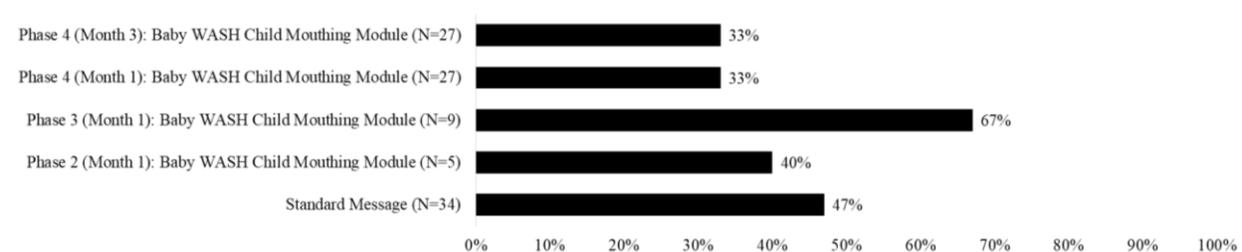


Figure 6. Child on a plastic or woven mat on the floor during an unannounced spot check

3.3.7 Discussion of quantitative findings

We observed a high proportion of caregivers that safely disposed of their child's feces in the toilet and washed their hands with soap after removing a child's feces in Phase 4. This improvement is likely

because of the additional semi-structured interviews conducted to explore the key barriers and facilitators to performing these behaviors and the corresponding refinements made to intervention communication modules. We observed large increases in handwashing with soap at food preparation events and the proportion of children fed on a mat during Phase 4. This improvement likely also reflects the additional formative research conducted through semi-structured interviews to identify the facilitators and barriers to performing these behaviors. Improvements in safe food storage practices were small, indicating that further formative research is needed on this behavior. There was no improvement in the proportion of children observed to be on a plastic or woven mat during unannounced spot checks, indicating again additional further research is needed on this behavior to identify approaches to increase this practice.

These findings indicate that the BabyWASH Safe Child Feces Disposal Module and BabyWASH Food Hygiene Module present a promising approach to facilitate safe child feces disposal and food hygiene practices in our study setting in Bangladesh. Future research is needed to observe if these practices can be sustained over time. More research is needed on the BabyWASH Child Mouthing Module.

3.4 LESSONS LEARNED THROUGH PHASE 4

Below we present some of the barriers and facilitators that emerged from the Phase 4 work, recommendations and suggestions from participants regarding the methods and tools used, as well as some recommendations for additional modifications to make to BabyWASH mHealth delivery in future iterations.

3.4.1 Barriers and facilitators of BabyWASH behaviors

Taken together, the qualitative and quantitative findings highlight the following barriers and facilitators of the selected BabyWASH behaviors.

Food hygiene: Availability of gas for cooking, low perceived self-efficacy to safely prepare and store food because of a busy work schedule or household tasks, perceived change in taste or smell if food is stored in refrigerator, and cold weather being viewed as a time when food does not need to be reheated were among the major barriers of safe food hygiene behavior.

We concluded that the following facilitated performing safe food hygiene behaviors: perceived risk of diarrhea from eating raw fruit and unwarmed leftovers; perceived risk of exposure to formalin from unwashed fruit; belief that reheating food will make it safe to eat and that covering food will protect it from dirt, insects, and rodents (response efficacy); perception that husbands preferred reheated food; and belief that neighbors preferred if they were served reheated food (injunctive norms).

Infant mouthing of soiled objects: Caregivers' perception that all children in their neighborhood put dirty things in their mouth (descriptive norms), lack of support for child supervision, low awareness about risk of diarrhea from children putting dirty things in their mouth, lack of access to clean child play spaces, and elders' perception that eating soil was not a problem for child health (social norms) were barriers to performing safe child mouthing practices. Facilitators of the behavior included high perceived disease risk from mouthing dirty things and adequate support for supervision of young children.

Safe feces disposal: Low perceived self-efficacy to clean child feces right away because of other household tasks and the greater distance from toilets, particularly during the rainy season were barriers to safe child feces disposal. High perceived risk of diarrhea from not disposing of child feces in a toilet, disgust around feces being present in the home and neighbors seeing the feces (social norms), and availability of child potties were facilitators of child feces disposal behaviors. Usually males believe that all household activities including cleanliness and childcare are the female's responsibility. As males believe females are responsible for household chores, they feel they do not need to know mHealth information.

3.4.2 Phase 4 pilot participants perceptions of various behavior change techniques used

Below are Phase 4 participant reactions when asked about the various behavior change techniques used. They do not reflect objective measures of method effectiveness, rather the point of view of study participants.

The BabyWASH mHealth voice and text messages were well received by pilot study participants. Participants mentioned that mobile messages were clear, while the content was useful to motivate them and make them more aware of the recommended behaviors. Mobile messages from Dr. Chobi Apa were valued because they were coming from a hospital and from a physician. Dr. Chobi was viewed as a credible source of health information. Participants reported that messages from Dr. Chobi Apa helped them to remember to perform the recommended behaviors and increased their awareness of the promoted behaviors for their better health and wellbeing:

Everyone will like it, as I told you if anyone wants to keep her child good, obviously she has to know it... No, everything was good in word.

She explained everything very nicely; and told all good things for our betterment.

One participant thought that people are more aware than before of washing hands with soap to prevent newly emerged diseases, like COVID-19. She also has realized that Dr. Chobi is right to prevent infectious diseases:

Yes, now they wash but before (-) ...Yes, we think (Dr. Chobi Apa) is right now ...Now what else, everybody has given importance, as if they don't wash CORONA will enter, but now we do. But we listened it earlier so... when we took him out from hospital from that time, we wash our hands.

Text vs. voice messages for the delivery of the BabyWASH mHealth program: Some pilot study participants preferred both voice and text messages while others preferred either one or the other. There were no technical problems reported in receiving the phone calls and SMS during the study period. Voice calls were preferred by some pilot study participants because the call came directly, and it was easy to understand, particularly for those that were illiterate:

The (text) messages that we receive remain in the mobile, and what is said we hear that. All are good.

I think talking by giving a call is better. Many people may not read the messages (text); or even do not read or check the messages. I even do not read messages in my mobile phone. So, should talk (by giving calls) so that people can listen to it and memorize.

One participant prefers to receive both types of messages (Voice + SMS) as most of the time her baby is sick or keeping her busy. So, if she misses the call, then she can read the SMS later when it is more convenient. Another participant said that she has read each text message:

I read occasionally. In between I was busy with my child as he was very sick. Even though I read many of them.... Yes, could not receive (phone calls) many of them, as I was busy with my child. He remains sick most of the time, suffers from cold.

The elderly and illiterate had difficulties handling the mobile technology. They needed assistance from others to obtain the messages from Dr. Chobi Apa:

She (my mother) doesn't know how to search the numbers and messages...Yes, she (my mother) used to receive calls and informed that Dr. Chobi Apa had called. _

I cannot read messages, (laughing...), and even cannot search for it.

A challenge with text messages, however, was that some phones did not support Bangla script. In this case, Bangla phonetic using English characters was sent; however, this was not always easily understood.

In addition, if text messages were longer than 160 characters, they were split into separate text messages that sometimes came in the wrong sequence.

Participants mentioned being enthusiastic to answer IVR quiz calls. Participants became confident with the opportunity of answering the quizzes' questions by pressing 1 or 2 of their mobile buttons. Most of them like to give the quiz answers and they prefer to receive these types of questions more in the future. Aklima is another famous character who they can easily relate to in their daily life experiences:

Yes, they asked questions and to press 1 many times. Yes, I got that many times. Liked this matter.... feel good...told that I have given right answer, it will be good if it is done, Doctor Chobi Apa told this.

By answering to this, many things have been learnt ...that you are doing right or wrong work.

Chobi Apa told about Aklima Apa. Aklima Apa always talks to her to get suggestions. Then Aklima Apa lost her mobile meanwhile, and she told Apa about that, and Apa also told that. And, as like she asks me what I think was right, and if that is right then told me to click 1 or 2. I clicked what I felt right.

However, it was difficult for some to respond to quiz calls as they did not know how to answer by pressing 1 or 2 on their mobile phone. One participant felt bad and hesitated to share with others on how they answered the quiz. The elderly also had difficulty answering the quiz by pressing the mobile buttons:

Sister, I can't understand that thing (quiz), I didn't press, ha-ha-ha (laughing).

I felt bad...I didn't tell about this to them (other relatives) If you make it understandable to us then we can do so...

My mother doesn't understand, she doesn't know how to click 1 or 2 but she listened only.

Accompanying mHealth with home visits: Most participants preferred both strategies: home visits by the health promoters and mHealth messaging for their better understanding of key behaviors. They recommended that we visit their home to explain the behaviors before sending them mobile messages. They also preferred to receive messages from the hospital through a mobile phone, as all households have a mobile phone. Meanwhile participants expect to get help from project staff on mobile functioning:

What do I think it will be the best if you come to our home, because everything is good to say face to face. Saying on phone is another thing. Sometimes phone can't be received, sometimes can't listen the words clearly. If you visit my home, you can talk with me even when we are busy, you can stay home, wait and have your say. I think it will be best if you visit us at home.

Sister, this is the mobile era, everyone has mobile. It would be good that brothers (Health Promoters) go door to door like this, and mobile, many people can use, can listen the information as well. How Apa (Dr. Chobi Sister) is doing with her voice, Ma-Sha-Allah (God's will), this is good.

There is a difference between talking face to face and talking on phone. In that case (to mass people) you should inform everyone over phone.

Suggestion means, you can go to others houses like you came to ours. Some people have problem at home probably, but no, I feel good that you come our house, Doctor Chobi Apa has sent voice message, sometimes she sent recordings, it is beneficial for me, now I can share with others; it feels good to me.

Hospital counseling: Hospital bedside counseling/health education visits by trained health promoters has encouraged participants to change their behaviors. Participants realized that their child's frequent diarrhea causes extra work for parents:

Then ...Sir (health promoter) discussed with me, he gave me the treatment. Even with me, Sir... (child's sound) my child was very young...as I got diarrhea so I feared my children will get too, that's why they gave us some solutions (child's sound).

It is important for that reason, for the children, if a child gets sick then mother suffers... Mother suffers, isn't it...need to stay at the hospital...No feeding, no bathing, the children suffers more than his mother, that's why ...Husband rush to the hospital-need to go back and forth for several times... So, can't go for works.

3.4.3 mHealth refinements

Based on the qualitative findings from the earlier phases of the pilot study, both voice and text messages were included in the BabyWASH mHealth program, additional quiz questions were added, and a summary text message were sent after all voice calls. The length of text messages was reduced to less than 160 characters, when possible, to ensure beneficiaries did not receive text messages split into segments. Program households were sent voice calls at 5 pm. During the recruitment process, we encouraged households to provide the phone numbers of the primary caregiver in the household, when available, and encouraged message sharing among household members during the pictorial modules as well as in the mobile messages themselves. We found during the pilot study that some Bangla script messages were difficult to understand, thus we simplified the language to be more easily understood.

Following Phase 4, the team made the following observations and recommendations for changes to the scale-up of future mHealth BabyWASH messaging:

Table 4. Observations and recommendations for changes to scaling mHealth BabyWASH messaging

KEY FINDINGS/ CHALLENGES	INTERVENTION REVISIONS
<ul style="list-style-type: none"> ▪ Some mHealth messages were difficult for household members to understand. ▪ Male household members were not always available to help with childcare. ▪ Some photos in the pictorial modules were not clear to pilot participants. 	<ul style="list-style-type: none"> ▪ We have changed some mHealth messages for improved understanding. ▪ We have added inspiring messages for fathers and how can they help their wives with household chores. ▪ Photos that were reported to be unclear by beneficiaries were retaken and tested in subsequent pilot households

4.0 DISCUSSION

This discussion draws on findings from the four pilot phases. The formative research described was a theory-driven and evidence-based approach to develop a BabyWASH mHealth program targeting food hygiene, child mouthing, and child feces disposal behaviors in urban Dhaka, Bangladesh. This is the first instance, to our knowledge, of formative research and intervention development for a BabyWASH mHealth program. We explored current practices and barriers and facilitators related to BabyWASH behaviors, and developed mobile messages and other intervention content based on our findings, guided by behavior change theories that acknowledge multi-level, multi-dimensional factors that influence behavior change and habit formation (Dreibelbis et al., 2013; Neal et al., 2016). We then tested our developed intervention in an iterative pilot study and modified the intervention content and delivery based on beneficiary preferences and acceptability, and feasibility of the BabyWASH mHealth program.

Based on findings from the pilot activities, we conclude that:

mHealth alone is not an effective strategy for effectively nudging and sustaining improved BabyWASH behaviors, forming new hygiene habits for improved infant health and growth.

However, mHealth can play a role in more comprehensive behavior change approaches to improve infant-related hygiene practices.

We added a pictorial module to the mobile component of the intervention based on beneficiary feedback, which was well received. These BabyWASH behaviors were essentially new and complex behaviors for caregivers, and researchers concluded that an intensive, interpersonal visit was required to introduce and negotiate the new practices. Based on reported difficulty understanding mobile messages and accessing and responding to IVR quiz messages, we added an in-person tutorial on mobile phone use. We also observed that female beneficiaries had lower rates of phone ownership than male beneficiaries and did not always receive program messages. This finding is consistent with previous reports, which found that 82% of male adults are mobile phone owners compared to only 55% of adult females in Bangladesh (Dreibelbis et al., 2013). Therefore, our behavioral recommendations, if delivered solely through mobile messages, may not have reached all female household members. Delivery of the pictorial modules in-person helped us ensure that program content was accessible to more program beneficiaries. Our findings highlight the importance of considering intervention approaches that ensure equity in access to intervention content for household members.

Few WASH studies focused on young children have explored caregiver perceptions around child mouthing behaviors (Reid et al., 2018). Most exploratory work has focused on child feces disposal and food hygiene (Wodnik et al., 2018; Takanashi et al., 2009; Gautam et al., 2017). Our child mouthing findings show that caregivers are aware of what children are mouthing and recognize risks of mouthing certain objects. In a separate study, we showed that child mouthing of soil and contaminated fomites in Bangladesh was frequent and associated with EE and impaired growth, and that soil collected from child play spaces contained pathogenic *E. coli* (Morita et al., 2017; George, Oldja et al., 2015). These findings are consistent with a previous study in rural Zimbabwe (George, Oldja et al., 2015). In this present research, some participants considered mouthing soil important for encouraging child growth. Future studies might develop easy-to-clean, affordable toys to facilitate safe mouthing behavior in this setting.

4.1 STUDY STRENGTHS AND LIMITATIONS

This study has several strengths. First, the 18-month duration of the formative research across four pilot phases gave us a detailed understanding of the facilitators and barriers to the promoted WASH behaviors and allowed us to modify the intervention to address these findings. Second, we tried multiple approaches to program delivery. Exploring mobile-only and mobile plus in-person delivery of

intervention content helped to identify which modalities were best for program delivery. Third, we made efforts in both program design and implementation to incorporate multiple caregivers of young children, both men and women, to promote balance in gender roles for performing the promoted behaviors.

This study had some limitations. We focused our formative research on two specific populations: previous CHoBI7 mHealth RCT households and recent diarrhea patient households. First, we focused our formative research on delivering the BabyWASH mHealth program to diarrhea patient households. Therefore, these findings may not be generalized to other populations. Second, we focused only on households who reported mobile phone ownership. So, these findings cannot be generalized to households that share their phone with another household. Third, our study was conducted in an urban setting of Bangladesh. This might not be generalized to other regions, especially in the rural areas of Bangladesh, or in other developing countries. Future studies should consider similar formative research in rural settings in Bangladesh. Fourth, we conducted semi-structured exit interviews of our pilot study with participants that comprised mostly women, because male participants were usually unavailable. Future studies should conduct the interviews with men to better understand how to incorporate their needs and schedules into our behavioral recommendations. Additional interviews with men may provide important insight into how to better balance household responsibilities related to WASH behaviors. Finally, we were not able to complete our full field activities (80% completed) within the timeframe due to the COVID-19 pandemic. The Government of Bangladesh extended the “Stay at Home Order” for the sixth time to May 30, 2020, and we were not able to carry out the remaining follow-up visits (20%) and the exit interviews (n=3) due to the unfortunate lockdown.

However, we identified several behavioral determinants at the structural level, such as availability of playgrounds and shared access to stoves for cooking that were outside the scope of our mHealth program but should be targeted through future neighborhood or city-wide programs.

4.2 GOVERNMENT ACCEPTABILITY OF BABYWASH MHEALTH MODULE

Government stakeholders were receptive to the use of mobile phone messages to deliver the BabyWASH program and expressed an interest in incorporating this program into their National Operational Plan. They mentioned that mobile messages can be delivered using the government platform and that this would reduce the cost of message delivery.

Currently, the Government of Bangladesh has modified the CHoBI7 mHealth approach, and is sending messages on WASH through mobile phones at scale as a measure to prevent COVID-19 and combat the ongoing pandemic. The messages are similar to what we have sent for our mHealth program to ensure child health. We hope the government will take necessary measures to address these issues to prevent not only diarrheal disease, but also other infectious diseases like COVID-19 by using their own mobile platform.

Don't cough and spit here and there as a measure for preventing CORONA virus. Don't touch nose, face, eyes with your hands. To prevent CORONA virus, wash your hands frequently with soap and water at least 20 seconds_ call at 16263 or 333 numbers to get health advice on emergency. _Health Directorate [collected]

Government stakeholders recommended both voice and text messages be sent to households, mentioning that they currently deliver both for their ongoing government programs. Government stakeholders emphasized the importance of voice calls for illiterate individuals (from our previous report).

4.3 RECOMMENDATIONS

There are several applicable recommendations for future WASH or BabyWASH mHealth programs to be taken away from this study:

1. Introducing new and unfamiliar behaviors may be difficult to communicate through mobile messages alone. An in-person visit and pictorial materials (e.g., cue cards) or demonstrations may be required. Adapting pictorial materials, such as a flipbook or cue cards, for mHealth delivery may be possible in a setting where smart phone ownership is high.
2. Households are likely to have variable access to WASH-enabling technology and infrastructure that would facilitate BabyWASH behavioral recommendations (e.g., access to a refrigerator or child potty, and uninterrupted access to stoves). When enabling technology is not provided by an intervention, alternative behavioral recommendations should be developed depending on what households do have. mHealth programs might consider sending mobile messages that are tailored specifically to household infrastructure and available technology.
3. A better balance of targeting men and women in WASH behavior change programs for child health is needed. We identified two barriers to more equitable delivery of WASH mHealth programs for both men and women. First, men may be the primary owner of mobile phones and not always share the mobile message content with female household members. In addition, female household members may not feel comfortable sharing their number because of concerns that their husbands may be suspicious of whom they were talking to on the phone. mHealth programs should enroll all household members to receive mobile intervention content to maximize chances of reaching women in the household, particularly at a time when men are more likely to be at home (e.g., the evening) to facilitate message sharing and to promote more gender equitable roles and responsibilities in caregiving.

Second, men were largely absent from female caregivers' narratives on existing BabyWASH practices, often because they are away from the home during the day. BabyWASH programs should identify behavioral recommendations specifically for men that they are able to practice when at home (e.g., help with evening food preparation).
4. Finally, mobile literacy may vary substantially in a target population. We recommend that future mHealth programs assess mobile literacy in their target audience and design mobile tutorials accordingly—this may require an in-person tutorial, as was the case in this setting.

Young children have unique exposure routes to fecal pathogens in the home environment, and BabyWASH interventions need to be developed and tested to limit exposure for susceptible pediatric populations. We conducted a theory-driven and evidence-based approach to developing a BabyWASH mHealth program to target food hygiene, child mouthing, and child feces disposal behaviors in urban Dhaka, Bangladesh. Future studies are needed to determine the feasibility of scaling this program, and to assess its effectiveness. This research provided several applicable recommendations for future WASH mHealth programs, and a model for formative research that could be adapted and applied in similar settings.

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ANNEX I: EXAMPLE BEHAVIOR CHANGE TECHNIQUES AND MOBILE MESSAGES INFORMED BY SYSTEM I PRINCIPLES

SYSTEM I DRIVER	SYSTEM I DRIVER DEFINITION	BEHAVIOR CHANGE TECHNIQUE	EXAMPLE MESSAGES
Context change	Create or capitalize on context change to drive new behavior	Life stage change	<p>Today, I ask you a question, which you have to answer by pressing 1 or 2 on your mobile.</p> <p>If a child defecates while the mother is busy with household work, should his/her father dispose of that feces in the toilet?</p> <p>If you think the father should dispose of that feces in the toilet, then press 1. And if you think that no father should do that task since this is women's work, then press 2 on mobile. It is free to reply.</p> <p>Ans 1: Thanks, that's right, both parents have the responsibility of keeping their children healthy and clean. So if the mother is busy with household work, and if the child defecates here and there, then the father should be clean his child and dispose of feces in a specific place such as the toilet, and washing your hands and the child by using soap or soapy water. Remember that your child's well-being is in your hands. Discuss with everyone in your family to keep healthy.</p> <p>Ans 2: Thanks for trying, both parents have the responsibility of keeping their children healthy and clean. So if the mother is busy with household work, and if the child defecates here and there, then the father should clean his child and dispose of feces in a specific place such as the toilet, and washing your hands and the child by using soap or soapy water. Remember that your child's well-being is in your hands. Discuss with everyone in your family to keep healthy.</p>

SYSTEM I DRIVER	SYSTEM I DRIVER DEFINITION	BEHAVIOR CHANGE TECHNIQUE	EXAMPLE MESSAGES
Leverage point of action reminders and cues	Remind people of the promoted behavior periodically, especially when they are in the appropriate context	Messages that help create salient cues at sites to remind individuals about share the message	<p>Aklima Apa lost her mobile. For this reason, she did not receive any of my messages. Her husband did receive these messages. However, he was very busy and did not always remember to share those messages with her.</p> <p>Aklima asked her husband to share these important messages, and now he shares with her when he returns from work.</p> <p>Aklima, What did you say to your husband?</p> <p>Darling (O babu's Father!) Please share the messages you received from Dr. Chobi Apa so we can keep our child healthy. I do not have a mobile now. I heard many important things from Dr. Chobi Apa before. I need to learn these things to keep our child healthy. Please share these messages with me when you return home from work. It is very important we both know the messages from Dr. Chobi Apa. Share the message!</p>
Manage physical availability	Ensure critical products and infrastructure are immediately and consistently physically available	Message providing instructions on market availability of WASH behavior-related hardware	<p>Is it okay to keep leftover food (bashikabar) outside the refrigerator during very cold weather? If you think "Yes" then press 1 on your mobile, or if you think "No" then press 2 on your mobile. You do not need to pay any money for answering this answer on your mobile.</p> <p>Ans. 1: Thank you for trying. You have to keep your leftover food (bashikabar) in your refrigerator, if you have one, even in this very cold weather. If you don't do that, then your foods can become contaminated with germs. Serve/eat your foods just immediately after cooking them and keep leftover food (bashikabar) in the refrigerator. For those who don't have a refrigerator, you should cover your foods and reheat them before eating.</p> <p>Stay healthy and take care, call you again!</p> <p>Ans. 2: Excellent, very good habits! You have to keep your leftover food (bashikabar) in your refrigerator even in this very cold weather. if you don't do that, then your foods will become contaminated with germs. Serve/eat your foods just immediately after cooking them and keep leftover food (bashikabar) in the refrigerator. For those who don't have a refrigerator, you should cover your foods and reheat them before eating.</p>

SYSTEM I DRIVER	SYSTEM I DRIVER DEFINITION	BEHAVIOR CHANGE TECHNIQUE	EXAMPLE MESSAGES
Modify friction for desired/undesired behaviors	Strategically increase friction for undesired behaviors and lessen them for desired ones	Message to discourage undesired behaviors and encourage desired behaviors	<p>When the cooked food you prepared for your family was delicious everyone enjoyed and praised you, correct?. And you enjoy cooking good meals for your family, right? What if this good food you made for your family had germs, that made your baby sick, and you had to go back to the hospital, How would you feel? You would be upset, right? You would have to spend unexpected money and lose time from work. Wouldn't this be a huge hassle?</p> <p>That's why I am telling you that you have to wash your both hands before preparing/cooking foods. Because, germs remain on our hands, and at the same time different types of chemicals can be on our fish/meats and leafy vegetables, which we often hear about on the news and watch on the television. However, you have to wash each of your foods carefully during food preparation and cooking as well washing both your hands with soapy water properly, so that your hands become clean from the germs and chemicals.</p>
Context change	Create or capitalize on context change to drive new behavior	Life stage change	<p>We have seen that most babies put dirty things they find in their mouth, like paper, socks, TV remote, mobile, and the clothes they wore. You might think that this is normal; however, these items have germs and dirt that might cause severe diarrhea if your children put these items in their mouth, causing your family to return to the hospital for treatment. You would have to spend unexpected money and lose time from work. Wouldn't this be a huge hassle?</p> <p>So, you need to take special care of your baby to keep them healthy; watch them closely when they play, and stop them from putting dirty things in their mouth. Keep your environment clean and help them to grow up properly.</p>

ANNEX 2: FINDINGS FROM COMPONENTS I AND 2



Formative Research for the Design of a Baby WASH Mobile Health Program

Dr. Shwapon Kumar Biswas (MBBS, MIH, MEH)
Senior Research Investigator
International Centre for Diarrhoeal Disease Research, Bangladesh

Solving public health problems through innovative scientific research

www.icddr.org

Background

- Diarrhea is a leading cause of death for young children globally

- Risk factors for diarrhea
 - Poor food hygiene practices
 - Child feces being not disposed of in a latrine
 - Child mouthing of contaminated fomites

- However, traditionally WASH interventions focus on handwashing with soap, water treatment, and improved latrines.



2

Formative Research for the Design of a Baby WASH mHealth Program

Am. J. Trop. Med. Hyg., 92(6), 2015, pp. 1117–1124
doi:10.4269/ajtmh.14-0672
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Geophagy Is Associated with Environmental Enteropathy and Stunting in Children in Rural Bangladesh

Christine Marie George,* Lauren Oldja, Shwapon Biswas, Jamie Perin, Gwenth O. Lee, Margaret Kosek, R. Bradley Sack, Shahnawaz Ahmed, Rashidul Haque, Tahmina Parvin, Ishrat J. Azmi, Sazzadul Islam Bhuyian, Kaiser A. Talukder, Shahnaj Mohammad, and Abu G. Faruque

Johns Hopkins University, Baltimore, Maryland; International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh



3

Formative Research for the Design of a Baby WASH mHealth Program

Mouthing of Soil Contaminated Objects is Associated with Environmental Enteropathy in Young Children

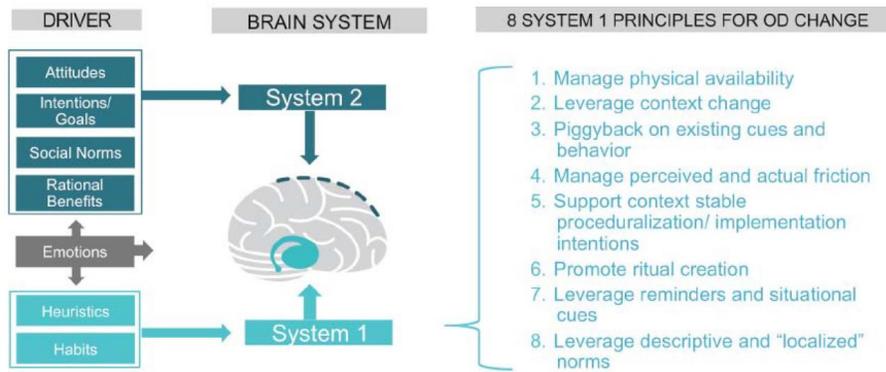
Tomohiko Morita¹, Jamie Perin¹, Lauren Oldja¹, Shwapon Biswas^{2,3}, R. Bradley Sack¹, Shahnawaz Ahmed², Rashidul Haque², Nurul Amin Bhuiyan², Tahmina Parvin², Sazzadul Islam Bhuyian², Mahmuda Akter², Kaisar A. Talukder², Mohammad Shahnaj², Abu G. Faruque² and Christine Marie George¹



4 Formative Research for the Design of a Baby WASH mHealth Program

System 1 & 2 Drivers of Behavior Change

- S1 driver : relatively automatic and cue driven factors
- S2 driver : relatively conscious and motivational factors



Neal et. al. 2016

6 Formative Research for the Design of a Baby WASH mHealth Program

Objective of the Baby WASH mHealth study

- **Objective 1:** Develop mHealth modules on safe child feces disposal, improved food hygiene practices, and on reducing childhood mouthing of soil and other contaminated fomites.
- **Objective 2:** Investigate the feasibility of implementing the new Baby WASH mHealth modules as part of the Bangladesh National Operational Plan for Communicable Disease Control.
- **Objective 3:** Disseminate the findings of Baby WASH mHealth study activities at the household, health facility, and government levels through workshops, policy briefs, scientific publications, and presentations.

7

Formative Research for the Design of a Baby WASH mHealth Program

Study Site and Period



8

Formative Research for the Design of a Baby WASH mHealth Program

Aims of the Formative Research

- **Aim 1:** Identify perceptions and practices around food hygiene, child mouthing, and child feces disposal behaviors among caregivers of young children and their household members.
- **Aim 2:** Identify barriers and facilitators to performing the target WASH behaviors.
- **Aim 3:** Identify beneficiary perceptions and preferences for delivering the Baby WASH mHealth program.
- **Aim 4:** Determine the feasibility of program delivery.

Intervention Development: Formative Research

- **31 Semi-Structured Interviews**
 - Government Stakeholders
 - Caregivers of Young Children
- **5 Group Discussions**
 - Mothers of Young Children
 - Fathers of Young Children
- **102 Pilot Households**
 - Diarrhea Patient Households



Sender of mHealth Program: Dr. Chobi



11 Formative Research for the Design of a Baby WASH mHealth Program

Baby WASH Food Hygiene mHealth Module: Key Behaviors



12 Formative Research for the Design of a Baby WASH mHealth Program

Baby WASH Food Hygiene mHealth Module : Manage physical availability (S1 Driver)



Dr. Chobi:

Hello ! I am Dr. Chobi from Mohakhali Cholera Hospital.

Flies can carry diseases. Keep flies off your food by using a fly cover or aluminum lid over cooked food. You can purchase a fly cover or aluminum lid at any bazar (Market) for only 35 BDT.

13

Formative Research for the Design of a Baby WASH mHealth Program

Baby WASH Child Mouthing mHealth Module: Key Behaviors



Baby WASH Child Mouthing mHealth Module: Piggy Backing on Existing Behavior (S1 Driver)



Dr. Chobi:

Hello, I am Dr. Chobi from Mohakhali Cholera Hospital.

Listen to my message for keeping your family healthy and happy.

At the same time you wash your clothes each day. Clean the toys and objects your child normally plays with using detergent powder and water. Dirt on these objects can make your child sick with diarrhea.

Keep your child healthy and happy! Please share the message with others.

Baby WASH Safe Child Feces Disposal mHealth Module: Key Behaviors



Baby WASH Safe Child Feces Disposal mHealth Module: Context Change (S1 Driver)



Message sharing

Dr. Chobi:

Hello. I am Dr. Chobi Apa from Mohakahli Cholera Hospital.

During the rainy season some caregivers throw their child feces outside their room on the ground or keep their child's potty with feces in the room until the rain stop.

This is not a good practice.

Always dispose of your child's feces in the toilet immediately, and wash you and your child's hands with soap or soapy water.

Keep your family healthy and happy. Please share the message with others.

17

Formative Research for the Design of a Baby WASH mHealth Program

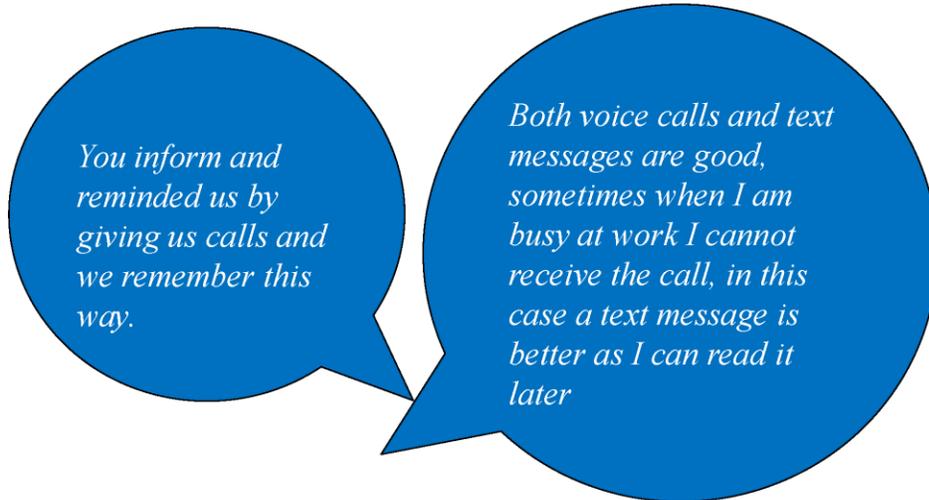
Acceptability of the Baby WASH mHealth Modules

Government stakeholders were very receptive to the use of mobile phone messages

[We] do not have a program for direct management of diarrhea patients; however we want to prevent diarrhea by advocacy communication, social mobilization, and early detection of the disease.

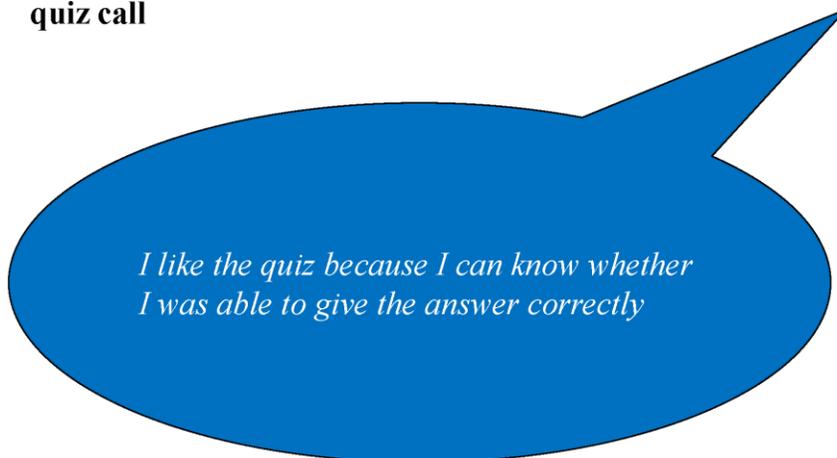
Acceptability of the Baby WASH mHealth Modules

Voice and text messages were well received by pilot participants and served as a reminder



Acceptability of the Baby WASH mHealth Modules

Participants were very enthusiastic to answer the IVR quiz call

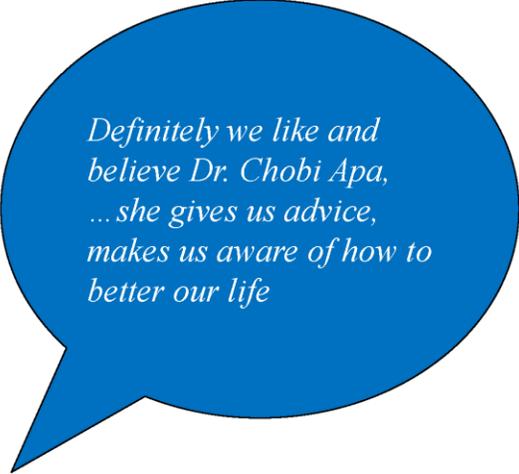


Acceptability of the Baby WASH mHealth Modules

Dr. Chobi was viewed as a credible source of health information



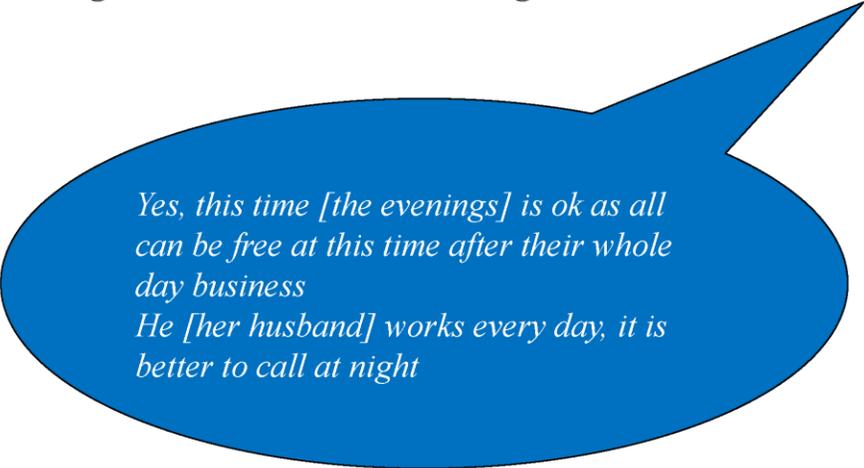
[These] messages are good; we have learnt many things from Dr. Chobi Apa's message.



Definitely we like and believe Dr. Chobi Apa, ... she gives us advice, makes us aware of how to better our life

Acceptability of the Baby WASH mHealth Modules

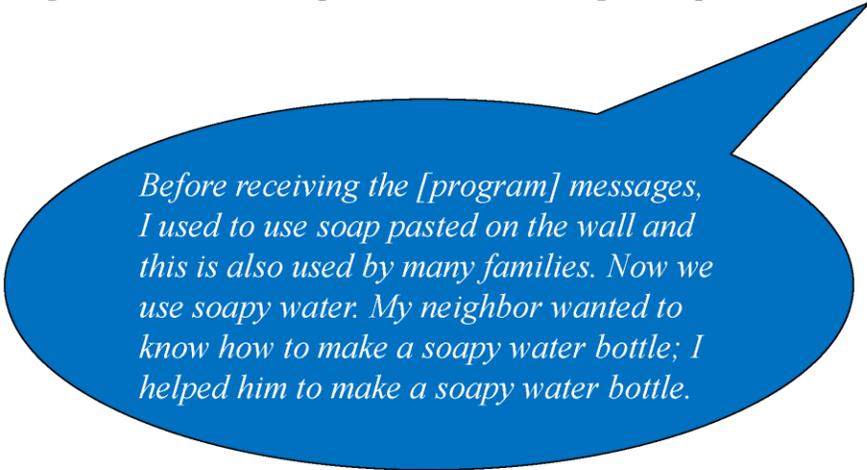
Timing of voice calls and text messages



*Yes, this time [the evenings] is ok as all can be free at this time after their whole day business
He [her husband] works every day, it is better to call at night*

Acceptability of the Baby WASH mHealth Modules

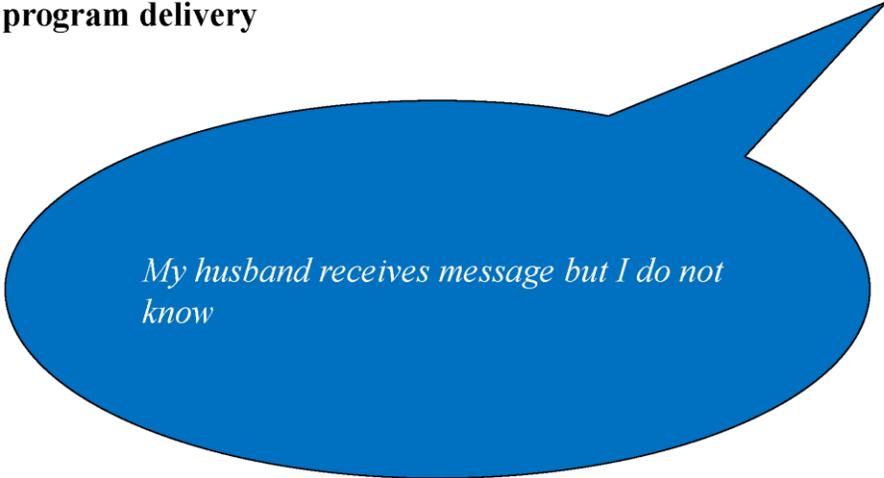
Mobile messages from Dr. Chobi were considered to be important for creating awareness and improving health



Before receiving the [program] messages, I used to use soap pasted on the wall and this is also used by many families. Now we use soapy water. My neighbor wanted to know how to make a soapy water bottle; I helped him to make a soapy water bottle.

Challenges: Pilot household's phone access and message sharing

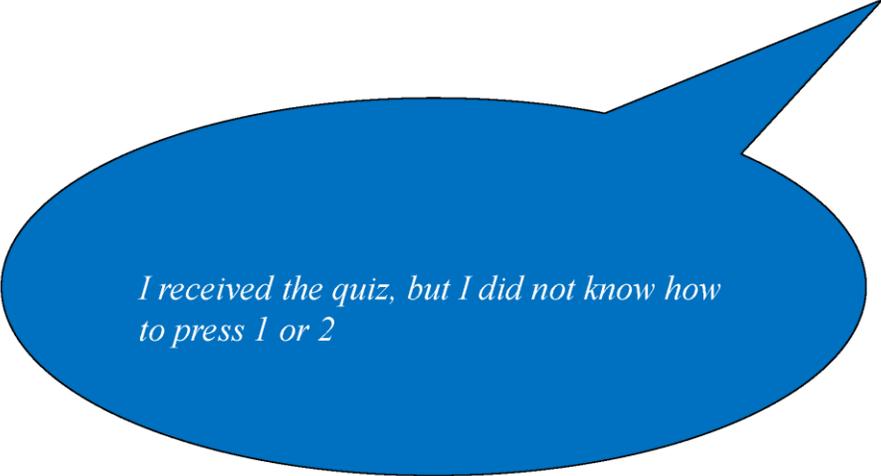
Phone access and message sharing emerged as a challenge for program delivery



My husband receives message but I do not know

Challenges: Responding quiz call

Initially it was difficult for some to respond to quiz calls



I received the quiz, but I did not know how to press 1 or 2

Intervention Refinements

- A recording of Dr. Chobi's IVR quiz message was during enrollment in the mHealth program.
- Encouraged households during enrollment in the mHealth program to provide the numbers of the primary caregiver in the household
- Encouraged sharing of mobile messages with other household members
- Reduced the number of key behaviors promoted, and targeted facilitators for performing key behaviors identified during formative research

Summary of Findings

- A theory-driven and evidence-based approach was implemented to develop and refine the Baby WASH mHealth program.
- The formative research findings indicate that the Baby WASH mHealth program has high user acceptability.
- Government stakeholders were very receptive to the use of mobile phone messages to deliver the Baby WASH program, and expressed an interest in incorporating this program in their National Operational Plan.

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Formative Research for the Design of a Baby WASH mHealth Program

Acknowledgement



Study Participants

All Field Research Assistants

Dr. Christine Marie George

Dr. Munirul Alam PhD

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Jahed Masud MS

Ismat Uddin Minhaj

28

Formative Research for the Design of a Baby WASH mHealth Program

This project has been funded

By



icddr,b thanks its core donors for their on-going support



Government of the People's
Republic of Bangladesh



ANNEX 3: FINDINGS FROM PILOT PHASES 1-3

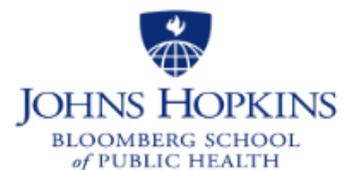
Formative Research Report Baby WASH Mobile Health Program Mobile Health Messaging:

An Innovative Approach to Promote Improved Caregiver and
Child Hygiene Practices in Bangladesh



International Centre for Diarrhoeal Disease Research, Bangladesh

Johns Hopkins School of Public Health



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Dr. Shwapon Kumar Biswas	Senior Research Investigator, icddr,b
Dr. Christine Marie George	Principal Investigator, Johns Hopkins School of Public Health
Mrs. Tahmina Parvin	Research Investigator, icddr,b
Dr. Munirul Alam	Principal Investigator, icddr,b

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Dr. Shirajum Monira, Fatema Zohura, Dr. M. Tasdik Hasan, Md. Sazzadul Islam Bhuyian, Jahed Masud, Ismat Minhaj, Fatema –Tuz Johura, Dr. Marzia Sultana, Indrajeet Barman, Elizabeth Thomas, Dr. Jamie Perin

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INTRODUCTION

Diarrheal diseases continue to be a major cause of mortality among young children globally, causing 500,000 deaths annually (1). The first two years of life are a critical window for child development (2, 3). The water, sanitation, and hygiene (WASH) behaviors of caregivers are important contributors to child health. Exposure to fecal pathogens due to poor hygiene and water treatment practices is associated with an increased risk of diarrheal disease and environmental enteropathy in young children (3-6).

Environmental enteropathy (EE) is a disorder defined by abnormal intestinal morphology which increases intestinal inflammation and reduces barrier function. This disorder has been associated with impaired growth in susceptible pediatric populations (7, 8). Previous studies have identified multiple risk factors for diarrheal diseases and environmental enteropathy among young children including poor food hygiene practices (9-11), child feces not being disposed of in a latrine, child mouthing of contaminated fomites, and the hand hygiene of caregivers of young children (4-6, 12-17). Therefore, it is important to understand the unique exposure routes to fecal pathogens for young children so that WASH interventions can be tailored for these susceptible pediatric populations.

Fecal oral transmission of pathogens through contaminated food is an important contributor to gastrointestinal infections in young children (5, 21-22). Poor food hygiene practices among caregivers have been associated with diarrhea in young children in Vietnam, and Indonesia (9, 11). Previous studies have shown that food stored without refrigeration can have rapid growth of pathogenic bacteria (18-20). A study conducted in Bangladesh, found that 40% of complementary food samples were contaminated with *E. coli*; and this contaminated food was associated with an increased risk of diarrhea among young children (25). Effective food hygiene interventions are of paramount importance to reduce the overall burden of diarrheal diseases in low and middle income countries globally.

Our recent study in Bangladesh found that mouthing of contaminated fomites such as bottles, toys, and wrappers with visible dirt, was observed in more than 60% of children under 2 years of age, and was associated with environmental enteropathy (16, 17). Furthermore, this study found that only 14% of caregivers were observed stopping their child from eating soil. However, despite this growing evidence showing an association between childhood mouthing of contaminated fomites and child health (17, 21), there has been no intervention studies published in Asia focusing on protecting young children from mouthing contaminated fomites in their play spaces. Thus, WASH interventions targeting child mouthing of contaminated fomites are of urgent need in setting such as Bangladesh.

Sanitation interventions implemented typically focus on construction of improved sanitation facilities. [11-13]. There is little attention given to safe disposal of feces from child open defecation events. This is despite unsafe child feces disposal being common globally, and being associated with pediatric diarrhea, environmental enteropathy, and impaired child growth (13, 14, 22). Improving safe disposal of child feces has the potential to significantly reduce childhood diarrhea, environmental enteropathy, and impaired growth among young children globally (23).

Community-based behavior change interventions are expensive and difficult to implement in low resource urban settings (24). The use of mobile technologies for delivery of health information referred to as mobile health (mHealth) is a promising low cost, scalable approach which can serve as a reflexive, cue-driven approach to facilitate behavior change (25-29). Mobile phone subscriptions have grown enormously worldwide more than doubling over the last 10 years (30). It was estimated in 2017, that there were 85 million unique mobile phone subscribers in Bangladesh, half of the country's population (31). Therefore, Bangladesh is an ideal setting for using mHealth to deliver behavior change programs.

STUDY RATIONALE

Most WASH programs focus on health education on diarrhea prevention without considering the contextual, psychosocial and technological factors driving the target WASH behaviors (32). Previous studies have shown that theory-driven approaches for intervention development are crucial for facilitating WASH behavior change (33, 34). The Integrated Behavioral Model for Water, Sanitation and Hygiene (IBM-WASH) considers the contextual, psychosocial and technological factors driving WASH behaviors at the community, household, individual, and habitual levels, and has been implemented for the successful development of WASH interventions (34-36). Many WASH programs focus on relatively conscious, ‘reflective’ drivers of behavior such as knowledge (e.g. germ theory), social norms (e.g. good manners), and emotions (e.g. disgust). However, there is growing evidence demonstrating that this approach is not effective in facilitating sustained behavior change (37, 38). Relatively unconscious ‘reflexive’ actions that are triggered automatically by familiar contextual cues are important for WASH habit formation (39, 40). Studies have shown that simple contextual cues, such as physical availability of soap and the presence of other ‘nudges’ such as the location of a handwashing station can be powerful determinants of maintaining handwashing with soap behaviors over time (41-43). However, few WASH programs have targeted these important drivers of WASH behavior change.

Neal *et al.*, 2016; describes System 1 (S1) and System 2 (S2) drivers of WASH behavior change. S1 drivers are relatively automatic and cue-driven factors and S2 drivers are relatively conscious and motivational factors. Behaviors that are performed frequently in the same setting are better predicted by S1 drivers that focus on habit formation and behaviors that are performed infrequently or in different settings are predicted by S2 driver that focuses on attitudes and intentions (44). Therefore, identifying S1 drivers can support the development of WASH interventions that target habitual behaviors to promote sustained behavior change. In this study we focus on developing and piloting mHealth interventions to target the S1 drivers of food hygiene, child feces disposal behaviors, and caregiver responses to child mouthing of contaminated fomites.

STUDY DESIGN: BABY WASH FORMATIVE RESEARCH

In Baby WASH mHealth Formative Research Study we take a theory-driven, evidence-based approach using qualitative and quantitative research methods to design a Baby WASH mHealth program targeting safe food hygiene, safe child mouthing, and safe child feces disposal practices. The Baby WASH research activities were a partnership between the Johns Hopkins Bloomberg School of Public Health, the Bangladesh Ministry of Health and Family Welfare, and the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b). The research activities were conducted in Dhaka, Bangladesh. The aims of the formative research were the following: (1) identify perceptions and practices around food hygiene, child mouthing, and child feces disposal behaviors among caregivers of young children and their household members; (2) identify barriers and facilitators to performing the target WASH behaviors; (3) identify beneficiary perceptions and preferences for delivering the Baby WASH mHealth program; and (4) determine the feasibility of program delivery. Formative research activities included both qualitative and quantitative methods to develop and test three mHealth modules. Qualitative methods included semi-structured interviews, focus group discussions, and intervention planning workshops. Quantitative methods included five-hour structured observation, unannounced spot checks to assess WASH conditions, and laboratory analyses of environmental and hand rinse samples to measure *E. coli*.

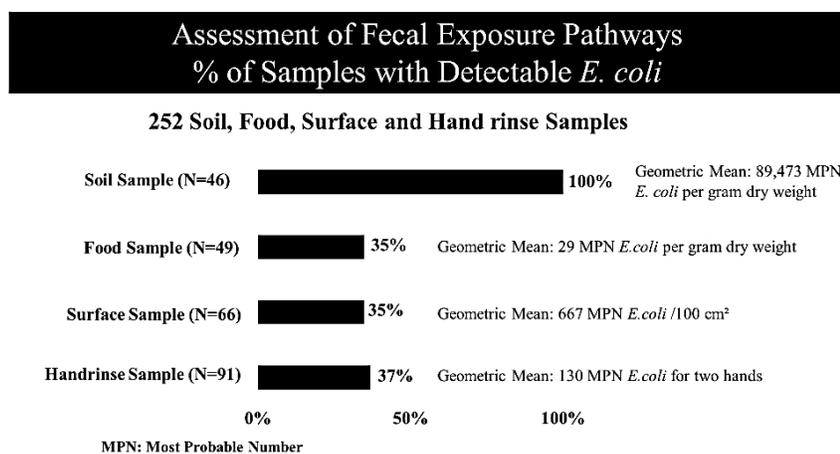
LABORATORY FINDINGS

METHODS

In the Baby WASH mHealth Formative Research Study, a total of 252 soil, food, hand rinse, water, and surface samples were collected from pilot households with a child under 5 years of age. Soil samples were collected from spaces where children were observed playing and surface samples were collected of objects children were observed putting in their mouth. Hand rinse samples were collected from children under 5 years of age and their caregivers. Food prepared for children under 5 years of age in the home was also collected. All samples were analyzed using the IDEXX Quanti-Tray System (Colilert-18 media; IDEXX Laboratories, Inc., Westbrook, ME) in the Molecular Ecology and Metagenomics Laboratory at icddr,b to enumerate *Escherichia coli* using the most probable number (MPN) method.

RESULTS

All soil samples had detectable *E. coli* (46), with a geometric mean of 89,473 MPN *E. coli* per gram dry weight. Thirty-five percent of surface samples had detectable *E. coli* (23/66). Balls (mean 667 *E. coli* MPN /100 cm²) and plastic bottles (281 *E. coli* MPN /100 cm²) were the items with the highest *E. coli* concentrations. All baby bottles had detectable *E. coli*. Other items with detectable *E. coli* included sticks, glasses, bowls, dolls, toy cars, and shoes. Thirty-five percent of food samples had detectable *E. coli* (17/49), with a geometric mean of 29 MPN *E. coli* per gram dry weight. Rice was the food with the high *E. coli* concentration (38 MPN *E. coli* per gram dry weight). Other foods with detectable *E. coli* included khichuri, noodles, banana, and *suji* (semolina). Forty-six percent of caregivers (13/28) had detectable *E. coli* on their hands (mean 88 *E. coli* MPN for two hands), and 33% of children under 5 years of age (21/63) (mean 149 *E. coli* MPN for two hands).



IMPLICATIONS FOR INTERVENTION DEVELOPMENT

Based on these findings we included in our Child Mouthing Module a section emphasizing the importance of cleaning child toys with detergent and water daily, and when children come back from playing with these toys outside. In our Food Hygiene Module we also emphasized the importance of reheating leftover food and stated that this should include rice. These results highlight the need for WASH interventions to reduce child contact with contaminated surfaces, and to improve food and hand hygiene.

QUALITATIVE FINDINGS

METHODS

Study settings and participation. The study was conducted in Dhaka, the capital city of Bangladesh. Dhaka is a densely populated city with an estimated population over 18 million. The eligibility criteria for diarrhea patient household members included in the semi-structured interviews, focus group discussions, and pilot study were the following: (1) at least one household member reporting ownership of an active mobile phone on the day of the enrollment; (2) having a child under 5 years of age in their household; and (3) not having a basin with running water in their home; and (4) planning to reside in Dhaka for the next 3 months (pilot participants only). Research activities were a partnership between the Johns Hopkins School of Public Health, the Bangladesh Ministry of Health and Family Welfare, and icddr,b.

Key Behaviors. The Baby WASH mHealth program targeted the following key behaviors: 1) handwashing with soap (or soapy water made using water and detergent powder) before food preparation, completely covering stored food, reheating leftover food, washing food eaten raw, and avoidance of street food (food hygiene module); 2) cleaning child toys and play spaces daily, disposing of trash in a waste bin, placing children on a mat when eating, and encouraging caregivers to watch young children closely to make sure they don't put 'dirty' things in their mouth such as soil, dirt or wrappers (child mouthing module (prevention of child mouthing of dirty fomites)); 3) disposal of child feces in the toilet, disposal of diapers and soiled clothes in a garbage bin, cleaning the child first after a defecation event then cleaning the site of defecation, cleaning child potties right after defecation events, and encouraging children to defecate on a raxine (plastic sheet) if no child potty is available or if children are too young to sit on a potty (safe child feces disposal module). These behaviors were selected based on findings from exploratory research conducted through semi-structured interviews and focus group discussions.

Formative Research Activities. Formative research had three components: (1) semi-structured interviews and focus group discussions; (2) intervention development through mHealth workshops; and (3) pilot studies of the Baby WASH mHealth program. The overall objective of these components was to develop and pilot Baby WASH mHealth modules on safe child feces disposal, food hygiene, and child mouthing behaviors. The semi-structured interviews, focus group discussions, and intervention planning workshops were conducted in parallel with the pilot. The aims of the formative research were the following: (1) identify perceptions and practices around food hygiene, child mouthing, and child feces disposal behaviors among caregivers of young children and their household members; (2) identify barriers and facilitators to performing the target WASH behaviors; (3) identify beneficiary perceptions and preferences for delivering the Baby WASH mHealth program; and (4) determine the feasibility of program delivery. Our target beneficiaries were diarrhea patient households.

Component 1 - Semi-structured interviews and group discussions

In total thirty-one semi-structured interviews were conducted from July 2018 to September 2019 with caregivers of young children and government stakeholders. The first set of interviews were conducted prior to the pilot with caregivers of young children in diarrhea patient households to understand current practices and preferences around food hygiene, child feces disposal and child mouthing behaviors for the development of the Baby WASH mHealth modules. Government stakeholders at the Bangladesh Ministry of Health and Family Welfare were interviewed to explore the feasibility of delivering the Baby WASH mHealth program as a national program. The interview guide for diarrhea patient households included questions on the type of food consumed by young children, food storage and reheating practices, caregivers' experiences with child mouthing of dirt or dirty objects, child toileting practices, child feces disposal practices, and preferences for mobile health message delivery.

Participants were a convenience sample of diarrhea patient households that had presented at Dhaka icddr,b hospital for treatment. Semi-structured interviews were conducted among doer and non-doers pilot

intervention participants to explore barriers and facilitators to performing the promoted food hygiene, child mouthing, and child feces disposal behaviors. Doer and non-doers were selected based on the quantitative findings from the pilot study. Semi-structured interviews ranged in length from 30 minutes to 1 hour. Interviews were conducted in Bangla, audio recorded, and transcribed.

Five focus group discussions with caregivers of young children were conducted from July 2018 to June 2019 to identify the existing practices and preferences around the key WASH behaviors, and to obtain feedback on the developed Baby WASH mHealth modules. Focus group discussion guides had questions on the daily activities of young children, behaviors and practices around food preparation and cooking, child feces disposal, child mouthing of objects, and preferences for mobile health message delivery. Each focus group discussion had between 8 to 15 caregivers. The duration of each focus group discussion ranged from 1.5 to 3 hours. Focus group discussions were conducted in a meeting room at the icddr,b project office, and were audio recorded and transcribed. Feedback received from focus group discussions was used to develop mobile messages, and refine existing mobile messages that had been developed during the mHealth workshops. All interview and focus group discussion transcripts and audio recordings were reviewed by qualitative research staff and summarized thematically. Thematic summaries were then reviewed by the research team to identify salient themes related to the program's target behaviors.

Component 2 – mHealth workshops

The Baby WASH mHealth program was developed during six mHealth workshops held from July 2018 to June 2019. The objective of these workshops was to develop and refine text and voice messages and the mHealth pictorial modules. These workshops were led by the study research team (including the study intervention and project coordinators, health promoters, and study investigators). During these workshops the team developed mobile message content and pictorial modules targeting S1 drivers based on findings from semi-structured interviews and focus group discussions, and informed by the IBM- WASH framework developed for each key behavior. Workshops ranged from half a day to a full day and included 6 to 29 participants. Mobile messages were written on a flipchart by the team and discussed and refined together as a group.

Component 3 – Pilot studies of the developed intervention

The objective of the pilot study was to identify the feasibility of implementing the Baby WASH program, and to identify challenges for program delivery. The pilot was an iterative process which was conducted in three phases and included 102 households. These activities are summarized in Figure 1.

Pilot Phase 1 (50 Households). The first phase of the pilot included 50 households that had been previously enrolled in the RCT of CHoBI7 mHealth program for 12 months. Thirty four of these phase 1 household were in the intervention arm of our previous RCT and had received a visit from a promoter, a handwashing station, a drinking water vessel with lid and tap, and bi-weekly mobile messages on handwashing with soap and water treatment for 12 months. Sixteen of these phase 1 pilot households were in the standard message arm of our previous RCT and had only received information on the use of oral rehydration solution (ORS) at hospital discharge after treatment of diarrhea (no prior mHealth messages). There were no in-person visits for intervention delivery in phase 1 of the pilot. Bi-weekly delivery of voice and text messages promoting the key Baby WASH behaviors was delivered to these households for up to 3 months. This phase focused on households with a child under 5 years of age.

Pilot Phase 2 (20 Households). In the second phase of the pilot, there were 15 households from the intervention arm and 5 households from the standard message arm of our previous RCT of the CHoBI7 mHealth program. The Baby WASH mHealth program was delivered only to the 15 households from the intervention arm of the previous RCT. These households received two home visits during the initial week of program delivery (based on beneficiary feedback from phase 1) where cue cards on the key behaviors were provided, followed by bi-weekly delivery of program voice and text messages for up to 1 month.

Figure 1. Pilot Activities for Refinement of the Baby WASH Mobile Health Program

Activity	Key Findings/Challenges	Intervention Revisions
<p>Phase 1 (50 Households)</p> <ul style="list-style-type: none"> Delivery of Baby WASH module to standard message and CHoBI7 mHealth program arm households from previous randomized controlled trial Bi-weekly voice and text messages were sent to households for 3 months (no home visits) Targeted households with children less than 5 years of age. 	<ul style="list-style-type: none"> Some pilot participants reported that the mobile messages were not sufficient for them to understand the key behaviors promoted, and that in-person visits were needed Child mouthing messages were less relevant for children 2 to 5 years old because the behavior decreased. Standard message arm households had more challenges with the promoted behaviors on handwashing with soap behaviors compared to CHoBI7 mHealth arm households Standard message arm households had more difficulty opening text messages and responding to interactive voice response (IVR) quiz messages Male household members were not always sharing mHealth messages with female caregivers Laboratory findings showed high fecal contamination on balls and plastic toys young children put in their mouth, and in rice given to young children. 	<ul style="list-style-type: none"> A pictorial module and cue cards were added for each key behavior. This module provided in-person guidance on how to receive text messages and respond to IVR quiz questions before mobile messages were sent to households. Included only households with a child under 2 years of age All mobile messages were tailored to target S1 relatively automatic, cue-driven drivers of behavior change to ensure both automatic and cue-driven factors and relatively conscious and motivational factors were being targeted. Only households in the CHoBI7 mHealth arm of the previous RCT were included The length of text messages was reduced to less than 160 characters Program households were sent voice calls at 5 PM Based on laboratory findings, cleaning child toys with detergent and water daily was added the Child Mouthing Module, and a section was added to the Food Hygiene Module explaining the importance of reheating and safely storing rice given to young children.
<p>Phase 2 (20 Households)</p> <ul style="list-style-type: none"> Delivery of Baby WASH module to only CHoBI7 mHealth program arm households from previous randomized controlled trial Health promoters delivered pictorial modules in two home visits Bi-weekly voice and text messages were sent to households for 1 month (no home visits) Targeted households with children less than 2 years of age. 	<ul style="list-style-type: none"> Male household members were not always engaged in key behaviors. Some beneficiaries had confusion on how existing practices related to the promoted key behaviors presented in the pictorial module. Some households reported that they didn't use soapy water because young children played with it Some photos in the pictorial modules were not clear to pilot participants 	<ul style="list-style-type: none"> Encouraged households during the recruitment process to provide the numbers of the primary caregiver in the household Added a slide to the pictorial module encouraging sharing of mobile messages with other household members (including children) Added a slide encouraging men to be engaged in performing the key WASH behaviors. All captions under the photos in the pictorial module were removed to make the pictorial module delivery more interactive, and to not discourage those that could not read the captions. Photos that were reported to be unclear by beneficiaries were retaken and tested in subsequent pilot households
<p>Phase 3 (32 Households)</p> <ul style="list-style-type: none"> Delivery of Baby WASH module to newly recruited diarrhea patient households Health promoters delivered pictorial modules during the health facility visits for treatment of diarrhea and two home visits during the 7 day high risk period after the diarrhea patient presented at the health facility. Bi-weekly voice and text messages were sent to households for 1 month (no home visits) Targeted households with children less than 2 years of age. 	<ul style="list-style-type: none"> Participants requested a more detailed introduction on how to respond to IVR quiz messages Pictorial modules allowed participants to more easily understand program messages. Caregivers had difficulty safely disposing of child feces and reheating leftover food Caregivers had difficulty remembering all the key behaviors promoted in each module 	<ul style="list-style-type: none"> Based on the finding that caregivers had difficulty remembering all the key behaviors promoted in each module, we reduced the number of key behaviors to three per module. Revised modules to target barriers and facilitators identified for completely covering leftover food, and safe child feces disposal in the Pilot Phase 3, after finding low uptake of these behaviors in our quantitative pilot assessment. Added instructions on the timing and duration of mHealth message delivery in the pictorial module delivered during health facility and home visits. A recording of Dr. Chobi's IVR quiz message was played in the health facility and in the home to introduce beneficiary households to the sender of program messages and to teach them how to respond to IVR quiz messages.

This phase focused on households with a child under 2 years of age. In the results section under “Intervention Refinement by Study Phase” we explain in detail the rationale for the changes made in program delivery.

Pilot Phase 3 (32 Households). In the third phase of the pilot, we included 32 newly recruited diarrhea patient household at Dhaka icddr,b hospital. There were 24 households that received the Baby WASH mHealth program and 8 households that received the standard ORS message. Program households were delivered a pictorial Baby WASH module by a promoter in the health facility and two home visits during the 7 day high risk period after the diarrhea patient presented at the hospital. These households also received a handwashing station and cue cards on the key behaviors, and bi-weekly voice and text messages for up to 1 month. This phase focused on households with a child under 2 years of age. In the

results section under “Intervention Refinement by Study Phase” we explain in detail the rationale for the changes made in program delivery.

Intervention Development

A theory-driven and evidence-based approach using qualitative research methods was implemented to design the Baby WASH mHealth program. Formative research findings were analyzed using the IBM-WASH framework to gain a better understanding of the multi-level, multidimensional contextual, psychosocial, and technological factors that were influencing key WASH behaviors and program delivery (34). Tables 1-3 show the IBM-WASH framework used for intervention development. Two characters delivered the mHealth messages, Dr. Chobi and Aklima. These characters were used in our previous CHoBI7 mHealth program. Dr. Chobi is a doctor at icddr,b hospital who calls and texts diarrhea patient households to share information and reminders on key WASH behaviors. She is sometimes also called “Dr. Chobi Apa,” meaning “Sister Dr. Chobi.” Aklima is a woman who brought her child to a health facility for diarrhea treatment, and who learned proper WASH behaviors from Dr. Chobi. Aklima shares how she uses Dr. Chobi’s advice to successfully keep her family safe from diarrheal disease (45).

mHealth messages were developed to target the following S1 drivers (Table 4): 1) managing physical availability; 2) leveraging context changes; 3) piggybacking on existing cues and behavior; 4) managing perceived and actual friction; 5) supporting context-stable repetition; 6) embedding ritualized elements in the behavior change process; 7) leveraging point-of-action reminders and situational cues; and 8) highlighting descriptive and “localized” norms. We used the VIAMO platform to deliver text, voice and interactive voice response (IVR) messages to pilot households. For IVR messages, participants were asked ‘quiz’ questions to assess their knowledge of key behaviors. Mobile messages were sent bi-weekly. Three pictorial modules targeting safe food hygiene, child mouthing and child feces disposal were developed. Health promoters delivered the pictorial modules during in-person visits for 30 minutes. Three cue cards were developed for each module (Figure 2). There was one cue card given to all program households showing a photo of Dr. Chobi, and the times she would be calling households (Figure 2, photo c). Food hygiene cue cards showed how to properly cover, store, and reheat cooked foods, and the key times for handwashing with soap during food preparation. The child mouthing cue cards showed how to properly supervise young children during play activities to prevent child mouthing of contaminated fomites, and cleaning of child play spaces and toys. The child feces disposal cue cards showed safe disposal of child feces, diapers, and soil clothes. Health promoters explained the content of cue-cards during in-person visits and asked households to hang them on the wall of their household.

Ethical approval

This study was approved by the Johns Hopkins Bloomberg School of Public Health institutional review board and the International Centre for Diarrhoeal Diseases Research (icddr,b) ethical review committee. All study participants provided written informed consent.

Figure 2. Baby WASH Mobile Health Program Cue Cards

Improved food hygiene



Safe child mouthing



Safe child feces disposal



RESULTS

The results presented here are those most salient to the development and refinement of the Baby WASH mHealth program, providing critical insights into the practices and preferences for interventions on food hygiene, child feces disposal, and child mouthing. Results are presented by key behavior and study component. Exploratory research conducted prior to the pilot, and how this informed intervention development is presented first. This is followed by preferences and recommendations provided by pilot participants during semi-structured interviews and focus group discussions, and intervention revisions made based on formative research findings.

Exploratory Research Findings

Food Hygiene Behaviors

Mothers of young children were typically the ones responsible for cooking in the home. However in some cases this responsibility was delegated to the child's grandmother if the mother was busy with work outside of the home. Food preparation (e.g. cutting vegetables and meat before cooking) was generally performed in the household's room (typically households in slum areas of Dhaka reside in a single room) followed by cooking on a stove in a communal kitchen. Men were usually not involved in food preparation. Caregivers mentioned that many husbands in their neighboring households did not help their wives to prepare food and many even stopped their older children from helping. Caregivers mentioned the

need for men to help with household tasks, and that men could help with bringing water jugs, onions, chili, and plates needed for food preparation, and watching children while food was being prepared:

Every father needs to come forward to keep their child safe. You should not be dependent only on one person. The person who does all household chores, also has to take care of the child, that will not work....He (husband) must have something to offer for her (his wife). Men can help in many ways.

Suppose you (the husband) came home and she (the wife) was working on something. Small tasks where (she) needs assistance, you (the husband) can assist her with tasks such as cutting vegetables ... taking care of the child. You (the husband) can have a walk with your baby and [while] your wife is doing other work for you. That's helps a lot.

For washing vegetables and fruits eaten raw household members stated they preferred water that was “still” in a bowl or bucket, over running water. This was because of the fear of formalin being present on fruits such as mangos, and the belief that soaking fruit in water for at least 30 minutes would remove the formalin. Fruit and vegetables items were typically soaked in a bowl of water, then the water was poured out of the bowl and these items were considered “safe” for consumption.

Most caregivers reported preparing separate food for young children such as khichuri, mixed vegetables, noodles, and soft rice. Adult foods were considered too spicy and not soft enough for children to eat:

I do not feed my child our curry with rice because we eat spicy curry, we also eat solid foods without gravy, we rarely feed him (child) solid foods.

Food that was prepared at home such as mixed vegetables were considered good for child health as these can be prepared at home with maintaining cleanliness whereas street food which is usually prepared without maintaining cleanliness was considered harmful for children. Caregivers preferred to give children only fresh food. Most caregivers reported preparing food for children three times per day, and two times a day for adults. Children were placed on the bed or floor to eat, and sometimes food fell on the ground and children picked it up to eat it. Some mothers placed their child on a *gamcha* (a cloth used to wipe) or raxine (plastic sheet) to eat on. Young children were generally not supervised when they are eating.

Many households used a food rack (*khanaduli*) to store food to protect it from flies, cockroaches, cats, rats, and lizard and to prevent children from playing with food (Figure 3).

I keep food in the food rack where ants can enter, but flies, mosquitoes, cockroaches cannot.

Some caregivers, however, did not cover food that was in the food rack. Fly covers were used by some caregivers, particularly for food that was still warm. Many caregivers stated that the food rack alone was sufficient to safely store food. Some caregivers mentioned cooked food should be stored at a higher safe place where children cannot reach it.

The majority of households reported owning a refrigerator. Fresh fruits and raw vegetables as well as raw fish and meat, and sometimes medicines such as suppositories were kept in the refrigerator. However, some participants preferred not to keep cooked food in the refrigerator because it changed the taste of the food. One participant mentioned that they cover food in the refrigerator to prevent foods from spreading their smells to each other.

We cover food in the fridge; otherwise smells will be transferred from one food to other food

The leftover food from dinner that is eaten the next morning is called “basi khabar”. Basi khabar if not rotten is usually reheated before eating, rotten basi khabar is thrown away. Sometimes basi khabar is given to young children. Some participants mentioned that they throw away basi khabar as this may cause an upset stomach.

Figure 3. Food Rack (Khanduli)



In areas without sufficient gas supplies, households eat food without reheating. Some households do not reheat refrigerated food before eating as to save time and gas, instead they take it out of the refrigerator and let it get warm again before eating:

Before eating we take out the food from the refrigerator. When it becomes normal temperature then we eat those foods (no reheating)

Relatives encouraged caregivers to cook food daily and feed the child fresh food. Some participants said reheated food tastes good and their husbands preferred reheated food, and that neighbors preferred if they served them food that was reheated:

When men stay at home, we give them reheated food. They (men) do not prefer food without reheating.

Adding water to rice is called '*Panta vaat*', a traditional food which is taken without reheating. *Panta vaat* is usually taken by adult members of the household, and not children. In cold

weather, participants mentioned that food can stay safe for a longer time without reheating and the morning's cooked food can be taken at lunch without reheating. However, one respondent mentioned that in the winter frequent reheating of stored food is needed because food gets cold and cold food does not taste good.

Participants stated children liked to eat street food such as *jhalmuri* (puffed rice with spices), *achar* (pickles), *chotpoti* (potatoes, chickpeas, onions with grated boiled eggs), and *fuska* (hollow puri with boiled chickpeas and mashed potatoes). Caregivers said eating street food was harmful because this food was not prepared maintaining proper cleanliness and children can get a stomach upset and diarrhea:

Nothing is good from outside but sometimes outside food is needed to feed child to make them calm

Store bought food such as canned juice and chips were considered harmful for children as they may cause an upset stomach because the dyes used for clothes were mentioned to be the same dyes used for juices.

Barriers and facilitators to performing safe food hygiene behaviors: Availability of gas for cooking, low perceived self-efficacy to safely prepare and store food because of a busy work schedule or household tasks, perceived change in taste or smell if food is stored in the refrigerator, and cold weather being viewed as a time when food did not need to be reheated were barriers of safe food hygiene behavior.

Whereas perceived risk of diarrhea from eating raw fruit and leftover, the perceived risk of exposure to formalin from not washing fruit, the belief that reheating food will make it safe to eat and that covering food will protect it from dirt, insects, and rodents (response efficacy), perception that husbands preferred reheated food, and the belief that neighbors preferred if they were served reheat food (injunctive norms) were facilitators to performing safe food hygiene behaviors.

Intervention development informed by exploratory research on food hygiene behaviors. Based on the exploratory research findings we included the word '*Basi Khabar*' to all mHealth messages describing leftover food. We developed mobile messages encouraging households to store their food in the refrigerator (if available) and to keep it covered tightly to ensure the food keeps its taste. The importance of using running water for washing fruits and vegetables eaten raw was explained. Voice and text

messages and the food hygiene pictorial module encouraged men to help bringing water jugs, onions, chili, and plates needed for food preparation, and watching children while food was being prepared. We included mobile messages explaining that the food rack alone was not sufficient for safe food storage, and that food still needs to be covered and reheated before eating. We also included mobile messages to be delivered during winter months explaining that even though it was cold outside food should still be reheated before eating to keep it safe, and that children should be placed on a clean raxine when eating to prevent them from dropping their food on the ground and putting this food back in their mouth.

Child Mouthing Behaviors

All caregivers mentioned that young children liked to play most of the day, and never “stayed put” they were always moving around. Participants reported these children like to play with sand, mud, pieces of brick, utensils, toys, and objects such as wrappers, match sticks, mobile phones, plastic bottles, television remotes, cigarette butts, discarded fruit, and leaves. Caregivers reported that their young children liked to watch television and use mobile phones to watch videos and play games. Some children also liked to brush their teeth with sand, put detergent powder in their mouth thinking it was sugar, licked the walls in their home, and dug holes in the ground to search for snakes. Children played both inside and outside of the house, with some children playing on the roadside because they were no playgrounds for children:

[My child] mostly plays in the road. Since there is no playground anywhere in Dhaka City they play on the roadside.

During play activities young children were often with other children in the neighborhood, and sometimes elder siblings or adult caregivers were present with them. Caregivers preferred children play inside the household with toys rather than be outside and getting dirty.

Caregivers reported observing their children and children from their neighborhood putting sand, mud, match sticks, pieces of bricks, human and animal feces, cigarette butts, discarded fruit, leaves, and shopping bags in their mouth. Children were stated to put everything in their mouth that they came close to because they did not understand what could be harmful for them:

Childs are small, they do not understand what things can make their stomach upset and what things they should not eat. We the guardians forbid them but they do not understand...They can put anything into their mouth, if they wish they can put even put snakes and scorpions into their mouth.

They [children] play the whole day. They put whatever dirt they get from anywhere in their mouth as they do not consider this dirt.

One caregiver mentioned that children sometimes dropped food on the ground when they were eating and that they picked this food up and ate it:

Many times we see if we give children a tasty food and it drops on the ground, they put that dropped food in their mouth.

The majority of caregivers did not like when their children put dirty things into their mouth because they thought this dirt could cause stomach aches and diarrhea. However, some caregivers, mostly elder caregivers, thought eating soil was not a problem for child health:

Mother-in-laws believe that children will eat the soil amount for which they are made up of by Allah [God].....usually children will grow up by eating soil and dirt.....usually all children in the village eat soil and dirt...Senior people say, don't worry. They will definitely be fine growing up eating soil.

Children from rural areas were thought by some to be able capable of digesting any type of dirt without stomach problems because their stomachs were stronger than urban children. Caregivers thought that it was normal for children to put items such as toys, television remotes, mobile phones and money in their mouth; however it was not normal for them to put feces and bricks into their mouth. Caregivers stated it was important to build awareness around child mouthing behavior, and that it was very important to supervise children closely when they played, to wash their hands if they get dirty, and to keep the household, child play spaces, and toys clean.

Barriers and facilitators to performing safe child mouthing behaviors. Caregivers' perception that all children in their neighborhood put dirty things in their mouth (descriptive norms), lack of support for child supervision, low awareness about the risk of diarrhea from children putting dirty things in their mouth, lack of access to clean child plays spaces, and elders perceiving that eating soil was not a problem for child health (social norms) were barriers to performing safe child mouthing practices.

Whereas high perceived disease risk from mouthing dirty things and adequate support for supervision of young children were facilitators of safe child mouthing behavior

Intervention development informed by exploratory research on safe child mouthing behaviors. Based on the exploratory research findings, we developed mobile messages that explained that even objects such as toys, television remotes, mobile phones, and money could carry germs that could cause diarrhea in young children. Both the pictorial modules and mobile messages stated the importance of supervising children closely during play, and encouraged men to help their wives with supervising young children. We explained that even children from rural areas could become sick from putting dirty things in their mouths. Mobile messages and the pictorial module discouraged child mouthing of bricks, and encouraged caregivers to clean toys regularly with detergent powder, sweep child play spaces daily, and to use a designated dustbin for trash kept in the home.

Child Feces Disposal Behaviors

Many caregivers were often busy with household tasks, and did not have time to dispose of child feces right away. Infants often defecated on bed covers, rags, or on a raxine (plastic sheet); these items were sometimes kept uncovered in a bowl overnight to be washed the next morning. Caregivers mostly used disposable diapers for infants. Some caregivers reported that households in their neighborhood threw these diapers in an open place where children were sometimes observed playing with them. Many caregivers used old clothes to remove child feces, and put feces in a plastic bag or dustbin. Some caregivers disposed of child feces in a drain, ditch, or garbage pile. Potties were not always cleaned after defecation events because caregivers were often busy with other household chores. Some caregivers' cleaned potties with only water and others used detergent powder or liquid soap. Some caregivers mentioned that if potties were washed with water alone germs could still be present. Most caregivers cleaned their child's feces and the place of defecation first, before cleaning up their child after a defecation event. Caregivers reported this was because they felt it would be disgusting if someone came and saw this feces in their home. One caregiver mentioned that she only cleans her child first after a defecation event if the child is crying, and that otherwise she cleans the area of defecation first:

If the child cries after defecation then I cleaned the child first, if the child remains playful I clean the place of defecation first.

Some caregivers described how disgusting it is when a child defecates all around the household and that this feces can be spread by feet. Other caregivers mentioned that if a child defecated around the household, flies could sit on this feces and spread diarrhea. In the rainy season, it was difficult to dispose of child feces in the toilet because toilets were often far away and the rain outside was heavy. During this time some caregivers threw their child's feces outside their room on the ground, or kept their child's potty with feces in the room until the rain stopped.

Most caregivers mentioned that there was no difference between child and adult feces, both were considered dangerous for child health. However, some caregivers thought adult feces was more dangerous than child feces because it had a smell while child feces did not:

Child feces are different as it has no foul smell. Adult feces has a more foul smell thus it is dangerous.

Barriers and facilitators to performing safe child feces disposal behaviors. Low perceived self-efficacy to clean child feces right away because of other household tasks and the far distance of toilets, particularly during the rainy season were barriers to safe child feces disposal. High perceived risk of diarrhea from not disposing of child feces in a toilet, disgust around feces being present in the home and neighbors seeing this feces (social norms), and availability of child potties were facilitators of child feces disposal behaviors.

Intervention development informed by exploratory research for safe child feces disposal behaviors. Based on the exploratory research findings, we recommended caregivers clean their child first before the area of defecation to prevent their child from crawling around and spreading their feces further around the household. Mobile messages emphasized the importance of cleaning child feces immediately after a defecation event and that child feces was just as dangerous as adult feces. We also recommended that male household members assist with child feces disposal.

Acceptability of Baby WASH mHealth Module

Government stakeholders were very receptive to the use of mobile phone messages to deliver the Baby WASH program, and expressed an interest in incorporating this program in their National Operational Plan. They mentioned that mobile messages can be delivered using the government platform and that this would reduce the cost of message delivery. Government stakeholders stated that the government does not currently have a program solely focused on diarrhea management, however they would like to prevent diarrhea through social mobilization, and early detection of patients:

[We] do not have a program for direct management of diarrhea patients; however we want to prevent diarrhea by advocacy communication, social mobilization, and early detection of patients.

The Baby WASH mHealth voice and text messages were well received by pilot study participants. Participants mentioned that mobile messages were clear and the content was useful to motivate them and make them more aware of the recommended behaviors. Caregivers said that the mobile message were easy for them to remember and made it easier for them to perform the recommended behaviors. Many caregivers also mentioned that their family members encouraged them to practice the new behaviors.

Mobile messages from Dr. Chobi were valued because they were coming from a hospital and from a physician. Dr. Chobi was viewed as a creditable source of health information. Participants reported that messages from Dr. Chobi helped them to remember to perform the recommended behaviors and increased their awareness of the promoted behaviors:

[These] messages are good; we have learnt many things from Dr. Chobi Apa's message. You inform and reminded us by giving us calls and we remember this way.

One participant mentioned that before receiving Dr. Chobi's messages her family use to use soap pasted on wall for handwashing. However, after receiving Dr. Chobi's messages they now use soapy water and her neighbor is interested in learning how to make soapy water:

Before receiving the [program] messages, I used to use soap pasted on the wall and this is also used by many families. Now we use soapy water. My neighbor wanted to know how to make a soapy water bottle; I helped him to make a soapy water bottle.

Most participants mentioned that mobile messages in combination with the pictorial module allowed them to understand the key behaviors promoted. However, some participants mentioned that mobile messages should focus more on the food children eat and provide more health-related information on how to prevent diarrhea. One caregiver mentioned that she did not consider health information coming to her phone to be of high importance as she receives many calls and messages from different places. Other participants said they wanted to meet Dr. Chobi in person:

Definitely we like and believe Dr. Chobi Apa , but if we can see her then we would have more satisfaction, she gives us advice, makes us aware of how to better our life

We always listen to her voice (Dr. Chobi) but never see her.

Some participants reported difficulty understanding the mobile messages that were sent. They recommended we come to their home to explain the behaviors before sending them mobile messages. Other participants mentioned that the phone was not sufficient to motivate them to perform the promoted behaviors, and that they should be taught these lessons in their home before receiving mobile messages:

Before sending [mobile] messages you have to make them understand.

It is not sufficient to tell them over phone, they should be taught in-person.

Participants recommended showing pictures in addition to mobile phone messages. Based on this feedback we delivered sections of our previous CHoBI7 pictorial module during two focus group discussions to obtain feedback. Participants stated that this type of approach was needed for the Baby WASH mHealth program:

Showing these types of picture will be very useful because if you explain to us by showing pictures, after that Dr. Chobi apa's messages will be understood better.

For the pictorial module delivery participants preferred home visits on the weekends between 3 to 5 PM.

Text and voice messages for the delivery of the Baby WASH mHealth program

Government stakeholders recommended both voice and text messages be sent to households, mentioning that they currently deliver both for their ongoing government programs. The government stakeholders emphasized the importance of voice calls for non-literate individuals.

Some pilot participants preferred both voice and text messages while others preferred either voice or text messages. Voice calls were preferred by some pilot participants because the call came directly and it was easy to understand even by those that were non-literate:

Since I cannot read, a voice call is good for me

A challenge, however, with voice calls was that they may come at a time when the person in the household was busy, or may be difficult to understand in a noisy place. Text messages were viewed as better by some because they could be shared easily with others and could be saved to be read at a later time:

Both voice calls and text messages are good, sometimes when I am busy at work I cannot receive the call, in this case a text message is better as I can read it later

A challenge with text messages, however, was that some phones were not supporting Bangla script. In this case Bangla phonetic using English characters was sent, however this was not always easily understood. In addition, if text messages were longer than 160 characters they were split into separate text messages that sometimes came in the wrong sequence.

Participants mentioned being enthusiastic to answer IVR quiz calls:

I like the quiz because I can know whether I was able to give the answer correctly

However it was difficult for some to respond to quiz calls because they did not know how to answer it by pressing 1 or 2 button on their mobile phone:

I received the quiz, but I did not know how to press 1 or 2

Additional challenges identified were not receiving messages due to a full inbox, changing sim cards frequently, children deleting text messages while playing games and the font used for Bangla script being difficult for some participants to understand.

Access to CHoBI7 Baby WASH mHealth messages

Participants reported sharing mobile messages with other household members. They recommended sharing these messages with neighbors as well. One participant mentioned that they could not read the text message so he sought help from their wife, and shared information from Dr. Chobi's voice messages with his family:

I get text messages but I cannot read them as I am not very educated so my wife helps me to read the text messages. When Dr. Chobi apa calls me and I share this information with my family

Female caregivers reported lower phone ownership than male household members. Some primary caregivers reported that mobile messages were received by their husbands, and were not always shared:

My husband receives message but I do not know

Participants recommended that program mobile messages be sent to both husbands and wives. Some female caregivers did not want to share their contact number during recruitment because of concerns that their husbands may be suspicious of whom they were talking to. Most participants reported wanting to receive program mobile messages between 4 to 8 pm and on Fridays (the weekend in Bangladesh).

They preferred this time because this was when most household members, including husbands, were available in their home:

Yes, this time [the evenings] is ok as all can be free at this time after their whole day business. He [her husband] works every day, it is better to call at night

Baby WASH Pictorial Module

Based on beneficiary feedback from the pilot, three pictorial modules were developed for each key behavior: safe food hygiene, child mouthing, and child feces disposal. Each module started with an introduction given by Dr. Chobi and Aklima, and then described how diarrheal diseases could be transmitted, included a discussion on current practices related to each key behavior promoted and how male household members could be engaged in these behaviors, encouraged those receiving program mobile messages to share these with other household members, and delivered a training how to receive voice and text messages and delete text messages when inboxes were full. Cue cards were also provided for households to keep, displaying the key behaviors and when they should be performed.

The pictorial modules were well received by pilot participants. Participants reported that the pictorial modules helped them to understand the key behaviors promoted:

Both [pictorial module and mobile messages] are good for me. There pictures can be seen and understood directly.

It is a good thing to show the pictures and explain at the same time

All participants mentioned that the pictorial modules were helpful in introducing them to the new behaviors:

We previously did not wash our hands before feeding our child, however now we wash our hands, we practice these good things; we dispose of feces in the toilet after defecation. These (pictorial modules) taught us and made us more aware.

When you speak (send a voice message) we listen, but showing us the photos make us to do the work exactly as it is shown in the photo

I liked the book (pictorial module) because it made us understood by showing pictures and discussing how germs can spread, how one can get diarrhea, risky period for diarrhea ...all these [things] matter, then discussing how to get rid of diarrhea, when to wash hands with soap, covering of food, having child sit on a mat ...

Cue cards were also well received by participants. They liked the cue cards because they reminded them to perform the promoted behaviors:

The [cue] cards are hanging on my wall; I see them the whole day. Always when I look around I see them..... [these cue cards] allow me to be more careful and check to make sure what I am doing is okay.

It has been good for us to have these cards (cue cards), We also can learn from looking at the photos of the cue cards... other people who come to visit or guests can also learn.

One caregiver mentioned that no photos of any type can be kept in the same room where prayer is performed, and she must turn the cards around so the photos are not showing during prayer:

I like the pictures [cue cards]. But I keep these pictures turned around facing the wall, because my sister uses this room for prayer.

Intervention Refinement

Based on the qualitative findings from the pilot study, both voice and text messages were included in the Baby WASH mHealth program, additional quiz questions were added, and summary text message were sent after all voice calls. The length of text messages was reduced to less than 160 characters, when possible, to ensure beneficiaries didn't receive text messages split into segments. Program households were sent voice calls at 5 PM. We encouraged households during the recruitment process to provide the numbers of the primary caregiver in the household, when available, and encouraged message sharing among household members during the pictorial modules as well as in the mobile messages themselves. We found during the pilot that some Bangla script messages were difficult to understand, we simplified the language for them to be more easily understood.

Intervention Refinement by Study Phase

Pilot Phase 1: In pilot phase 1, we identified that the standard message arm households from our previous RCT had more challenges with the promoted behaviors on handwashing with soap at stool and food related events compared to CHoBI7 mHealth arm households. This was likely because the standard message arm had not received the icddr,b handwashing station or previous mobile messages promoting handwashing with soap behavior. Standard message arm households from the previous RCT also reported more difficulty opening text messages and responding to IVR messages. This was likely because they had not received the mHealth tutorial on responding to IVR, voice, and text messages provided in the CHoBI7 mHealth arm of the previous RCT during in-person visits. Based on these findings, we only included households in the CHoBI7 mHealth arm of the previous RCT in the pilot phase 2, rather than combining both arms together. We found that child mouthing messages were less relevant to households with

children over 2 years of age because this behavior decreased substantially after this age. This led us to focus on households with children under 2 years of age in all subsequent phases. Some pilot participants reported that the mobile messages were not sufficient for them to understand the key behaviors promoted, and that in-person visits were needed. This led to the addition of the pictorial modules and cue cards to introduce households to the new key behaviors promoted in each Baby WASH mHealth module, and to provide in-person guidance on how to receive text messages and respond to IVR quiz questions before mobile messages were sent to households. All mobile messages were also tailored to target S1 relatively automatic, cue-driven drivers of behavior change to ensure both automatic and cue-driven factors *and* relatively conscious and motivational factors were being targeted. Based on the laboratory findings which showed high fecal contamination on balls and plastic toys children put in their mouth, we added cleaning child toys with detergent and water daily and when children come back from playing with toys outside to the Child Mouthing Module. A section was also added to the Food Hygiene Module explaining the importance of reheating and safely storing rice given to young children, based on the high fecal contamination found in the rice given to young children during our laboratory analysis.

Pilot Phase 2: In pilot phase 2, we added two home visits for delivery of the Baby WASH pictorial modules, in addition to bi-weekly delivery of mobile messages to program households. Based on feedback from pilot participants, we changed the order of the pictorial modules to start first by showing the current practices observed in many households, and then following this by explaining the promoted key behaviors. We added a slide to the pictorial module encouraging sharing of mobile messages with other household members (including children), and added a slide encouraging men to be engaged in performing the key WASH behaviors. All captions under the photos in the pictorial module were removed to make the pictorial module delivery more interactive, and to not discourage those that could not read the captions. Some households reported that they didn't use soapy water because young children played with it. This led us to add a slide on how to hang the soapy water bottle higher up to keep it away from young children (under two years). Some photos in the pictorial modules were not clear to pilot participants; these were retaken and tested in subsequent pilot households. We added a slide on the importance of washing foods eaten raw with running water before feeding them to a child.

Pilot Phase 3: In pilot phase 3, we explored delivery of the Baby WASH mHealth program to households recently admitted to a health facility for the treatment of diarrhea. The time patients and their household members spend at a health facility for the treatment of diarrhea presents the opportunity to deliver WASH behavior change communication when perceived severity of diarrheal diseases and the perceived benefits of the promoted WASH behaviors are likely the highest (46, 47). Program households had three in-person visits for delivery of the pictorial Baby WASH module. One in-person visit in the health facility during treatment for diarrhea and two home visits during the 7 day high risk period after the diarrhea patient presented at the hospital. This sequenced aligned with the intervention delivery in our recent successful trial of the CHoBI7 mHealth program (George et al. submitted 2019). We added slides to the pictorial module on the 7 day high risk period for transmission of diarrheal diseases after the diarrhea patient presented at the health facility, and provided a handwashing station and a soapy water bottle. Instructions on the timing and duration of delivery of program mHealth messages were included on a slide with a photo of Dr. Chobi, and households were asked to provide the phone number of the primary caregiver. A recording of Dr. Chobi's IVR quiz message was also played in the health facility and in the home to introduce beneficiary households to the sender of program messages and to teach them how to respond to IVR quiz messages. Based on the finding that caregivers had difficulty remembering all the key behaviors promoted in each module, we reduced the number of key behaviors to three per module in mobile messages and the pictorial module. We also put further emphasis on completely covering leftover food, and safe child feces disposal in our pictorial module and mobile messages after finding the uptake of these behaviors was low in our quantitative pilot.

Table 1: The IBM-WASH Framework Applied to the Development of the Baby WASH mHealth Module on Safe Food Hygiene Behaviors Based on Qualitative Findings

IBM-WASH Dimension	Contextual factors	Psychosocial factors	Technology factors
Structural/ Societal	<ul style="list-style-type: none"> Female household members mostly responsible for food preparation In hot weather food is reheated more frequently than cold weather 	<ul style="list-style-type: none"> Commitment of government to implement national programs focused on diarrhea prevention, and delivery of public health information using a mobile platform 	
Community/ Health Facility	<ul style="list-style-type: none"> Access to stoves, gas, and water 	<ul style="list-style-type: none"> Commitment to practice handwashing with soap during food preparation and use a fly cover or lid Collective efficacy for supporting and maintaining hand hygiene practices during food preparation Relatives encourage caregivers to cook food daily and feed young children fresh food Neighbors prefer being served cooked food 	<ul style="list-style-type: none"> Access to a handwashing station and its location Availability of a refrigerator
Household/ Interpersonal	<ul style="list-style-type: none"> Availability of a food rack in the household 	<ul style="list-style-type: none"> Perception that during cold weather leftover food can stay safe for longer time Perceived disease risk from giving young children leftover food Perception that husbands prefer being served reheated food. Perception that husbands in neighboring households do not help their wives too prepare food, and may even stop their older children from helping. 	<ul style="list-style-type: none"> Shared kitchen/gas burner
Individual	<ul style="list-style-type: none"> Many caregivers have a busy work schedule or are busy with household tasks 	<ul style="list-style-type: none"> Low perceived self-efficacy to safely prepare and store food because of a busy work schedule or household tasks Perceived change in taste or smell if food is stored in the refrigerator Perception that a food rack alone is sufficient to store food Caregivers knowledge of soapy water preparation Perception that the food rack alone was sufficient to safely store food 	<ul style="list-style-type: none"> Soapy water is low cost, and easy to prepare Low perceived need for covering food if it is in a food rack
Habitual		<ul style="list-style-type: none"> Existing handwashing habits Outcome expectancy that following the recommendations contained in mobile messages will reduce disease 	<ul style="list-style-type: none"> Handwashing station near the kitchen serves as a cue for handwashing with soap Voice and text messages serve as reminders to perform the safe food hygiene behaviors.

Table 2: The IBM-WASH Framework Applied to the Development of the Baby WASH mHealth Module on Safe Child Mouthing Behaviors Based on Qualitative Findings

IBM-WASH Dimension	Contextual factors	Psychosocial factors	Technology factors
Structural	<ul style="list-style-type: none"> • Female household members are mostly responsible for supervising young children • Lack of access to clean municipal play spaces in Dhaka 	<ul style="list-style-type: none"> • Commitment of government to implement national programs focused on diarrhea prevention, and delivery of public health information using a mobile platform 	
Community/ Health Facility	<ul style="list-style-type: none"> • Lack of access to daycare 	<ul style="list-style-type: none"> • Perception that all children in their neighborhood put dirty things in their mouth 	<ul style="list-style-type: none"> • Low cost toys for young children are available in the market • Low cost plastic mats are available in the market
Household/ Interpersonal	<ul style="list-style-type: none"> • Parents work outside the home, therefore older siblings or grandmothers are often responsible for childcare • Lack of clean play spaces on household compound • Lack of adequate support for child supervision 	<ul style="list-style-type: none"> • Aspirations to have a clean play space for young children 	
Individual	<ul style="list-style-type: none"> • Young child during the first two years of life exhibit frequent exploratory play behavior as they learn about their environment • Young children often play with dirty objects such as sand, pieces of bricks, discarded, wrappers, match sticks, mobile phones, and sometimes feces • Children often play in the street without supervision 	<ul style="list-style-type: none"> • High perceived risk of diarrhea and stomach aches if children put dirty things in their mouth • Perception by elders that eating soil was not a problem for child health • Perception that children from rural areas were able eat dirt without stomach problems • Perception that it is too difficult to stop children from putting soil in their mouth 	
Habitual	<ul style="list-style-type: none"> • Caregivers are not habituated with cleaning toys 	<ul style="list-style-type: none"> • Outcome expectancy that following the recommendations contained in mobile messages will reduce disease 	<ul style="list-style-type: none"> • Voice and text messages serve as reminders to perform the safe child mouthing behaviors

Table 3: The IBM-WASH Framework Applied to the Development of the Baby WASH mHealth Module on Safe Child Feces Disposal Behaviors Based on Qualitative Findings

IBM-WASH Dimension	Contextual factors	Psychosocial factors	Technology factors
Structural	<ul style="list-style-type: none"> □ Female household members are mostly responsible for disposal of child feces □ Disposal of child feces in a toilet is challenging during the rainy season because of far distance of shared latrines 	<ul style="list-style-type: none"> • Commitment of government to implement national programs focused on diarrhea prevention, and delivery of public health information using a mobile platform 	
Community / Health Facility		<ul style="list-style-type: none"> • Perception that many households in the community use a child potty, however do not clean it immediately or properly with soap and water 	<ul style="list-style-type: none"> • Availability of child potties • Location of the shared latrines
Household	<ul style="list-style-type: none"> • Mothers are mainly responsible for cleaning children and disposing of feces after a child defecation event 	<ul style="list-style-type: none"> • Perception that neighbors throw child feces including diapers in open spaces 	<ul style="list-style-type: none"> • Access to shared latrines
Individual	<ul style="list-style-type: none"> • Parents work outside the home, therefore older siblings or grandmothers are often responsible for childcare • Younger children cannot use the potty and often spread their feces around the household • Caregivers may be busy with other household tasks and not have time to clean bedding after a child defecation event 	<ul style="list-style-type: none"> • Child feces are considered as dangerous as adult • High perceived risk of diarrhea from not disposing of child feces in a toilet • Low perceived self-efficacy to clean child feces right away because of other household tasks and the far distance of toilets • Concerns around neighbors seeing their child's feces on the bed or the floor of their home 	
Habitual	<ul style="list-style-type: none"> • Most caregivers clean the place of defecation before cleaning the child after a defecation event 	<ul style="list-style-type: none"> • Existing habits for disposal of child feces • Outcome expectancy that following the recommendations contained in mobile messages will reduce disease 	<ul style="list-style-type: none"> • Voice and text messages as reminders to perform the safe child feces disposal behaviors

Table 4: Example of the Theory-Driven Approach for Development of Baby WASH mHealth messages: System 1 Drivers of Behavior Change			
System 1 Driver	System 1 Driver Definition	Behavior Change Technique	Example Messages
Manage physical availability	Ensure critical products and infrastructure are immediately and consistently physically available	Message providing instructions on market availability of WASH behavior related hardware	Flies can carry diseases. Keep flies off your food by using a food cover over cooked food. You can purchase a fly cover at any bazar for 15-50 taka.
Context change	Create or capitalize on context change to drive new behavior	Life stage change	Look at how your child is growing! So beautiful are our little ones as they learn to walk. Now when they defecate they spread feces everywhere. It's a big mess! Do you think cleaning your child first after defecation will reduce this mess? If you think "YES" press 1 and if 'NO' then press "2".
Piggybacking on existing behaviors	Piggyback on other existing established behaviors in a community	Piggybacking cleaning child toys and other objects with existing behaviors	At the same time you wash your clothes each day. Clean the toys and objects your child normally plays with using detergent powder and water. Dirt on these objects can make your child sick with diarrhea. Keep your child health and happy!
Modify friction for desired/undesired behaviors	Strategically increase friction for the undesired behaviors and lessen it for desired ones	Message to discourage undesired behaviors and encourage desired behaviors	It may seem hard at first to always wash your hands with soap. However handwashing with soap can be easy. A soapy water bottle is easy to make. Just add six capful of detergent to a half liter plastic bottle and then add water. Now your soapy water is ready!
Context stable repetition	Reward repeated use at the same place and time	Messages that reward context-stable use or action or promoted behaviors	Have you disposed of your child's feces in the toilet today? Press "1" if Yes or Press "2" if No Pressed 1: "Great Job! Always dispose of your child's feces in the toilet, and wash your hands after with soapy water. Keep your family healthy!" Pressed 2: "Keep trying! Always dispose of your child's feces in the toilet, and wash your hands after with soapy water. Keep your family healthy!"
Embedded Ritualized elements	Inclusion of ritualized elements in the new behavior to promote adoption	Messages that integrate promoted behaviors into ritualized cultural practices	When we dispose of our child's feces here and there. This brings dirtiness to where we live and can contaminate our water. We are required to always keep ourselves and our homes clean as it is said 'cleanliness is the part of holiness' Share the message!
Leverage point of action reminders and cues	Reminding people of the promoted behavior periodically, especially when they are in the appropriate context	Messages that help create salient cues at sites to remind individuals of the new meaning of the space.	When you look at your courtyard, what do you see? You see a special place where your child plays, not a toilet. If your child defecates in the courtyard use a scooper to remove the feces, dispose of the feces in a latrine, and wash your hands and your child's hands with soapy water. Keep your courtyard a fun and safe space for your child to play.
Leverage Descriptive and Localized norms	Descriptive and localized norms that reduce cognitive demands	Messages that highlight and develop norms using IVR mHealth responses from households enrolled in the study.	80% of caregivers in your neighborhood reported stopping their child when they put dirty objects in their mouth when they were playing. Like others in your neighborhood protect your child from diarrhea by always watching your child when they play outside and stopping them from putting dirty objects in their mouth.

QUANTITATIVE FINDINGS

METHODS

To assess household conditions, unannounced spot checks were performed in pilot households 1 month after enrollment to assess: (1) the presence of a plastic or woven mat on the floor; and (2) whether stored food was covered completely with a lid or fly cover. To observe food reheating, and child feces disposal and handwashing practices, 5-hour structured observation was conducted in pilot households 1 month after enrollment. Safe child feces disposal was defined as disposal of child feces in the toilet. Unannounced spot checks were conducted before structured observation visits. **Sample sizes for the pilot were small, and were only used to assess trends not statistical significance.**

RESULTS

Child on a plastic or woven mat on the floor during unannounced spot checks

In the Baby WASH Child Mouthing Module one of the promoted behavior was to have children sit on a plastic or woven mat when eating and playing to reduce contact with contaminated surfaces in their play spaces. During unannounced spot check visits, 40% of pilot phase 2 households and 67% of pilot phase 3 households had a child presence on a plastic or woven mat on the floor compared to 27% in standard message arm at the 1-month follow-up.

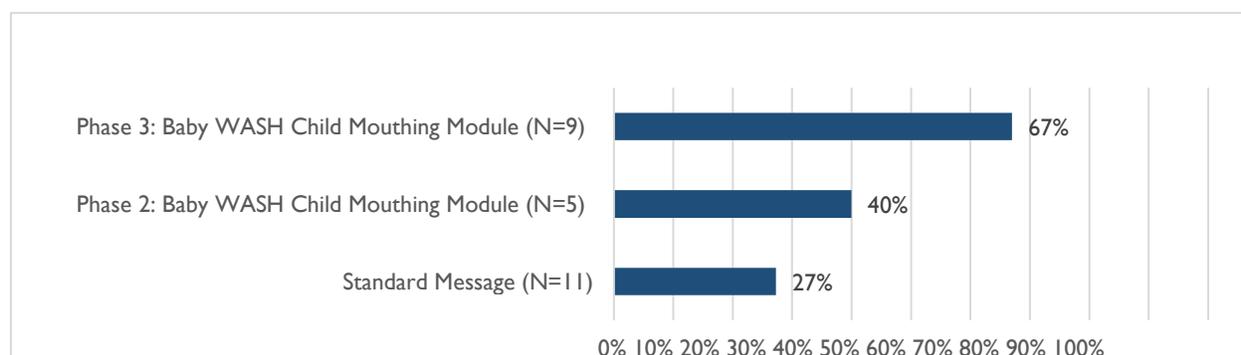


Figure 1. Child on a plastic or woven mat on the floor during an unannounced spot check

Caregiver handwashing with soap after cleaning a child's feces during structured observation

In the Baby WASH Safe Child Feces Disposal Module, one of the promoted behaviors was handwashing with soap after cleaning a child's feces. During 5-hour structured observation, 33% of pilot phase 2 caregivers and 57% of pilot phase 3 caregivers were observed handwashing with soap after cleaning a child's feces compared to 29% of caregivers in the standard message arm at the 1 month follow-up.

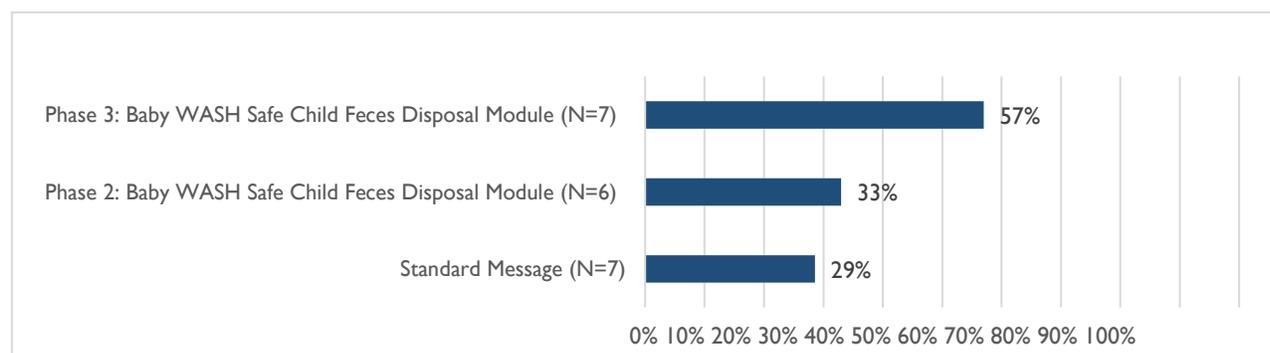


Figure 2. Caregiver's handwashing with soap after cleaning child feces during an observation

Caregiver safe disposal of child feces during structured observation

In the Baby WASH Safe Child Feces Disposal Module, one of the promoted behaviors was for caregivers to dispose of child feces in the toilet. During 5-hour structured observation, 50% of pilot phase 2 caregivers and 43% of pilot phase 3 caregivers disposed of child feces in the toilet, this is compared to 38% in the standard message arm at the 1 month follow-up.

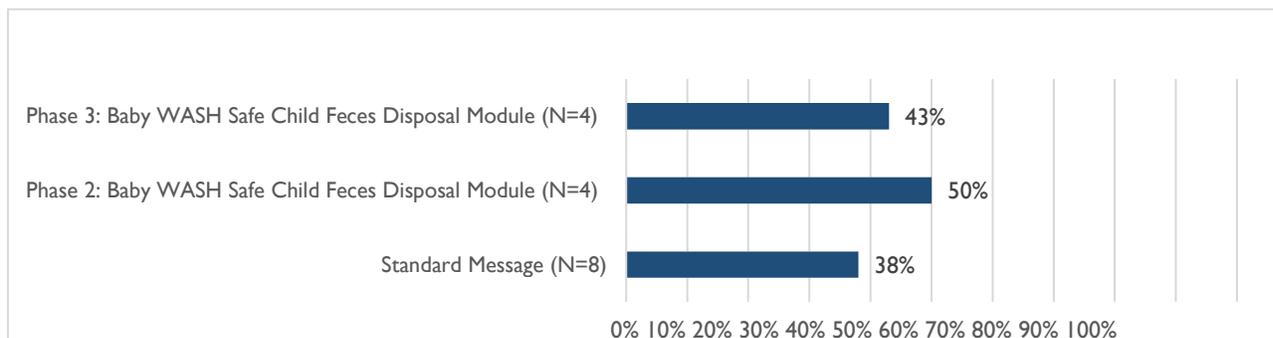


Figure 3. Caregiver safe disposal of child feces during 5-hour structured observation

Safe food storage during unannounced spot checks

In the Baby WASH Food Hygiene Module, one of the promoted behaviors was to completely cover all cooked foods in the household. During unannounced spot checks, 79% of pilot phase 2 households and 47% of pilot phase 3 households had leftover food completely covered, compared to 35% in standard message arm at the 1-month follow-up.

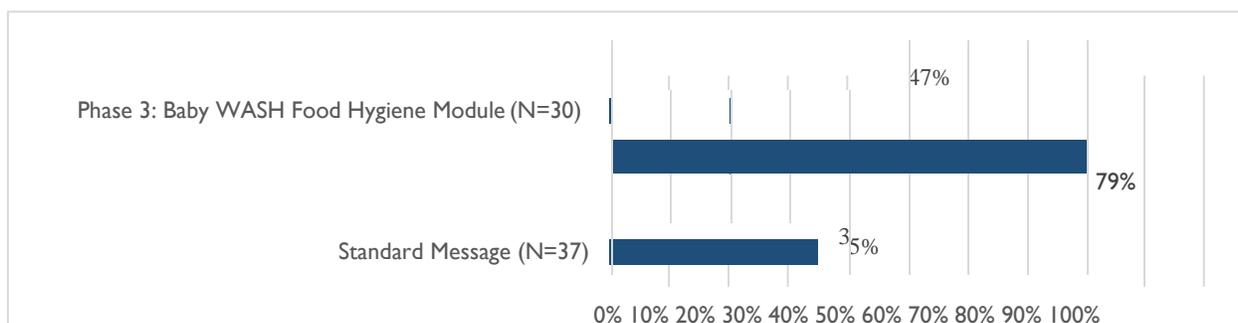


Figure 4. Food completely covered during unannounced spot checks

Reheating leftover food for at least 5 minutes during structured observation

In the Baby WASH Food Hygiene Module, one behavior promoted was reheating of leftover food until bubbles or steam started to come from the food. As a proxy measure of this behavior during structured observation we assessed how many household reheated their leftover food for at least 5 minutes before eating. All households in pilot phases 2 and 3 that ate cooked leftover food were observed reheating this food for at least 5 minutes, compared to two out of five households in the standard message arm.

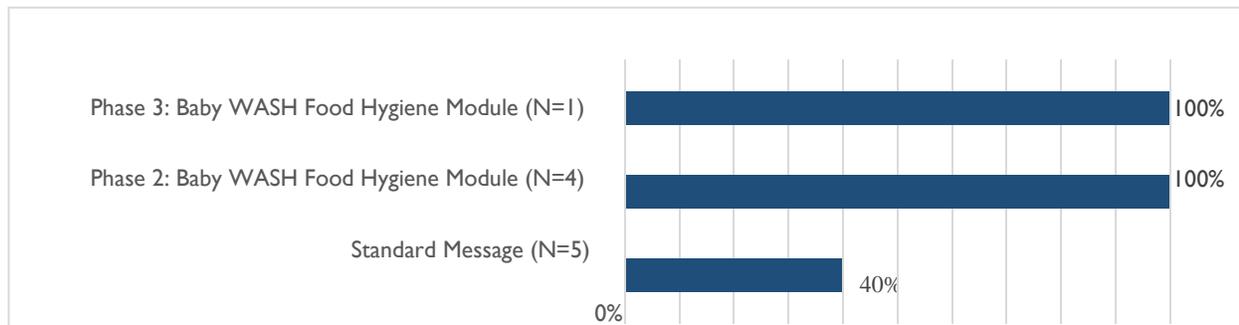


Figure 5. Household members observed reheating food for 5 minutes before eating

IMPLICATIONS FOR INTERVENTION DEVELOPMENT

We observed a high proportion of households that had their child on a plastic or woven during unannounced spot checks in the Baby WASH Child Mouthing Module arm. We also observed high handwashing with soap after cleaning a child’s feces in the Baby WASH Safe Child Feces Disposal Module arm. However, we observed low safe disposal of child feces. This finding indicates that further refinement is needed to this module to facilitate increased safe child feces disposal practices. We plan to conduct additional semi-structured interviews to explore the key barriers and facilitators to performing this behavior that we can target in our next round of piloting. We observed a high proportion of households reheating their stored food for at least 5 minutes in the Food Hygiene module arm. However, we observed a decline in this behavior from Pilot Phase 2 to 3. We plan to again explore the key barriers and facilitators to performing this behavior that we can target in our next round of piloting.

CONCLUSIONS

A theory-driven and evidence-based approach was implemented to develop and refine the Baby WASH mHealth program targeting safe food hygiene, child mouthing, and child feces disposal behaviors in urban Dhaka, Bangladesh. The formative research findings indicate that the Baby WASH mHealth program has high user acceptability and is feasible to deliver to diarrhea patient households. The formative research explored the current practices, barriers and facilitators of performing key behaviors, beneficiary preferences for intervention delivery, and the acceptability and feasibility of delivery of the Baby WASH mHealth program through semi-structured interview and focus group discussions. The mobile messages and pictorial modules developed to target key behaviors were tested in a pilot study. The pilot study was conducted in three phases to refine the intervention based on beneficiary feedback. mHealth planning workshops were conducted to draft and refine mobile messages and pictorial modules. This the first study, to the authors’ knowledge, to conduct formative research for the development of a Baby WASH mHealth program.

Most WASH programs develop interventions without considering the contextual, psychosocial, and technological factors driving WASH behaviors (34, 48). In this study we applied the IBM- WASH framework to our key behaviors to gain a better understanding of the multi-level, multidimensional contextual, psychosocial, and technological factors that were influencing our key behaviors and program delivery. Self-efficacy to dispose of child feces safely, social norms around disposal of child feces, perceived disease risk, and availability of child potties were drivers of child feces disposal behaviors. Husbands’ preferences for preparation of leftover food, gender roles around food preparation, hot and cold weather, access to gas, and current use of a food rack for food storage were drivers of food hygiene behaviors. Descriptive norms around child mouthing behaviors, lack of adequate support for child supervision, the busy work schedule of parents, lack of clean play spaces, and elders perceiving that

eating soil was not a problem for child health were drivers of child mouthing behavior. Consistent with our findings, a study conducted in Kenya found that personal beliefs and social opportunity were latent factors associated with hygienic behaviors for food preparation and storage, and perceptions of feces, social opportunity, and reflective motivation were the latent factors associated with a safe child play environment (3).

We added a pictorial module to the Baby WASH mHealth program based on beneficiary feedback. We observed that female beneficiaries had lower rates of phone ownerships than male beneficiaries. In addition, some participants reported difficulty understanding mobile messages without an in-person introduction to the key WASH behaviors, and that some participants needed a tutorial on how to access and respond to IVR quiz messages. Delivery of the pictorial modules allowed us to overcome many of these challenges through insuring program content was accessible to all program beneficiaries. In Bangladesh, 82% of male adults are mobile phone owners compared to only 55% of adult females (49). Our findings highlight the importance of considering intervention approaches that ensure equity in access to message content.

This is the first report, to our knowledge, describing the qualitative research conducted to design a Baby WASH mHealth program delivered to households. Previous Baby WASH studies and programs have focused on frequent in-person visits for intervention delivery (50, 51).

Furthermore, few studies targeting young children have focused on caregiver perceptions around child mouthing behaviors. Most studies instead focus on child feces disposal and food hygiene. Our recent work in Bangladesh has shown that child mouthing of soil and contaminated fomites is associated with environmental enteropathy and impaired growth, and that soil collected from child play spaces contained pathogenic *E.coli* (17, 52). These findings are consistent with a previous study in rural Zimbabwe which found that young children frequently put soil and animal feces in their mouth during play, and that this soil had high concentrations of *E.coli* (53). Another study from rural Zimbabwe identified *Clostridium difficile*, a pathogenic bacteria responsible for diarrhea, in soil samples (54). Young children in low and middle income countries frequently come into contact with fecal pathogen during play, and human feces and animals can serve as vectors for transporting these pathogens to child play spaces (55). Future studies are needed to develop theory-driven evidence-based approaches for implementing Baby WASH programs.

Our formative research focused on developing mobile messages targeting S1 driver of behavior change to leverage context changes, highlight descriptive and localized norms around key behaviors, piggyback on to existing behaviors, and manage physical availability of enabling technology. Few WASH programs target S1 drivers of behavior change during program delivery (43, 56) A study conducted in rural Bangladesh observed that physical availability of soap and water at a designated handwashing place increased handwashing practices with soap behaviors (43). Another study conducted in Bangladesh among primary school students used nudges to encourage handwashing with soap after using the toilet use (56). Future studies should conduct formative research to develop WASH programs targeting S1 drivers of behavior change in different low resource settings globally.

This study presents a theory-driven and evidence-based approach for intervention development that can be implemented for the development of future Baby WASH mHealth programs in low- resource settings. Future studies are needed to determine the feasibility of scaling this program across Bangladesh.

NEXT STEPS

Based on Pilot Phase 3 findings we have refined our Baby WASH modules on safe child feces disposal, child mouthing, and food hygiene to include the below revisions. We plan to evaluate this module in a Phase 4 of piloting which will include 100 households. To assess household conditions, unannounced spot checks will be performed in pilot households 7 days, 1 month, and 3 months after enrollment to assess: (1) the presence of a plastic or woven mat on the floor; and stored food being covered completely with a lid or fly cover. To observe food reheating, handwashing, and child feces disposal practices, 5-hour structured observation will be conducted in pilot households 7 days, 1 month and 3 months after enrollment. Unannounced spot checks will be conducted before structured observation visits. We will also conduct additional semi- structured interviews and focus group discussions in Phase 3 and 4 households.

Revisions to modules based on Phase 3 pilot findings:

- ✓ Based on the finding that caregivers had difficulty remembering all the key behaviors promoted in each module, we reduced the number of key behaviors to three per module.
- ✓ Revised modules to target barriers and facilitators identified for completely covering leftover food, and safe child feces disposal in the Pilot Phase 3, after finding low uptake of these behaviors in our quantitative pilot assessment.
- ✓ Added instructions on the timing and duration of mHealth message delivery in the pictorial module delivered during health facility and home visits.
- ✓ A recording of Dr. Chobi's IVR quiz message was played in the health facility and in the home to introduce beneficiary households to the sender of program messages and to teach them how to respond to IVR quiz messages.

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ANNEX 4: NATIONAL AND GLOBAL DISSEMINATION OF FINDINGS

The CHoBI7 BabyWASH team participated in numerous dissemination-related activities since the start of the grant period. The team has one peer-reviewed article published in the *American Journal of Tropical Medicine and Hygiene* and made two presentations on the formative research findings at international scientific meetings, at the 2019 University of North Carolina Water and Health Conference, and the American Society for Tropical Medicine and Hygiene (ASTMH) in 2019. More dissemination activities on this hygiene-related behavior communication will take place involving Bangladesh government stakeholders once the COVID-19 lockdown is over.

We presented the Phase 3 BabyWASH formative research findings at a technical session of the UNC annual meeting;

- Formative research for the design of a baby wash, sanitation, and hygiene (BabyWASH) Mobile Health Program in Bangladesh. (2019). Shwapon Kumar Biswas, Jahed Masud, Tahmina Parvin, Fatema Zohura Munirul Alam, Christine M. George.

In addition, we presented the BabyWASH formative research and laboratory findings at the ASTMH 68th annual meeting;

- Prevalence of Fecal Pathogens in Soil, Food, Food, Hand and Surface Samples from Households in Slums of Dhaka, Bangladesh: Evidence Based Development of BabyWASH Intervention. Fatema-tuz Johura, Christine M. George, Munirul Alam.

The Phase 3 findings have been published in the *American Journal of Tropical Medicine and Hygiene*, accepted in August 2020 and published in October 2020: Formative research for the design of a baby wash, sanitation and hygiene (BabyWASH) Mobile Health Program in Bangladesh. Shwapon Biswas, Jahed Masud, Elizabeth D. Thomas, Fatema Zohura, Tasdik Hasan, Tahmina Parvin, Md. Sazzadul Islam Bhuyian, Ismat Minhaj, Fatema –Tuz Johura, Marzia Sultana, Jamie Perin, Shirajum Monira, Munirul Alam, Christine Marie George.

Per WASHPaLS standard indicators, we tracked 505 people with increased knowledge of WASH approaches/tools through exposure to WASHPaLS events, communications materials, and products throughout the whole study period, from 2018 to 2020.

Photos of Intervention Activities



Photo 1. Jospital visit; Photo 2. Handwashing demonstration; Photo 3. Household visit

Photos of Evaluation Activities



Photo 4. Household visit



Photo 5. Household observation



Photo 6. CHoBI7 Study Team at icddr,b with Dr. Munirul Alam and Dr. Christine M. George

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