EVALUATING THE EFFECTS OF A CHILD-FOCUSED WATER, SANITATION, AND HYGIENE (WASH) INTERVENTION IN LAOS

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DISSERTATION ABSTRACT

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Title: Evaluating the Effects of a Child-Focused Water, Sanitation, and Hygiene (WASH) Intervention in Laos

Young children living in poverty in low- and middle-income countries are more likely to experience undernutrition, infectious diseases, environmental contaminants, and unstimulating surroundings. Exposure to such risks during the first 1,000 days of life leads to significant inequalities in a child's developmental trajectory. Child-focused water, sanitation, and hygiene (WASH) interventions have the potential to help create improved environmental conditions that are necessary for children to thrive. The current study examined the effects of a low-cost, easily scalable child-focused WASH intervention (targeting children ages 0-3) that was delivered in a single session to caregivers in Laos, a lower-middle income country in Southeast Asia. Specifically, we examined the effects of the child-focused WASH intervention on caregiver and child outcomes when the intervention was delivered independently, and in combination with a similarly efficient intervention focused on responsive caregiver stimulation. Although the primary focus of this paper was to document the effects of the child-focused WASH intervention, we also examined synergistic effects related to the combination of the child-focused WASH and responsive stimulation interventions.

Our results support the overall effectiveness of the WASH intervention on a number of important dimensions. First, caregivers found the WASH intervention to be beneficial to themselves and their children, and most believed that child-focused WASH behaviors would be easy to put into practice. Second, the WASH intervention had significant benefits with large effect sizes on caregiver WASH knowledge and self-reported WASH practices at one month post-intervention. The WASH intervention did not, however, appear to influence child physical growth outcomes or cognitive/language development by one month post-intervention. Nevertheless, children were less likely to experience a diarrheal episode post-intervention if their caregivers received the WASH intervention in addition to a responsive stimulation intervention. Together, these findings suggest that even a brief, single-session of a child-focused WASH intervention can produce short-term measurable effects on caregiver and child outcomes, especially when combined with a similarly efficient responsive stimulation intervention.

This dissertation includes unpublished coauthored material.

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I dedicate this dissertation to all the infants and children around the world.
May you be happy, healthy, and live to your fullest potential.

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CHAPTER I

INTRODUCTION

This manuscript contains unpublished co-authored material. M. Fong, C. Lattanavong, O. Inthachith, and J. Measelle contributed substantially to the study described in this manuscript. I designed the study with M. Fong. Data collection was organized by C. Lattanavang and O. Inthachith. M. Fong took the lead on designing and overseeing the responsive stimulation intervention described in this manuscript. I took the lead on designing and overseeing the WASH intervention described in this manuscript. I was the primary contributor to this manuscript. I analyzed the data and wrote this manuscript with input and editorial assistance from J. Measelle.

There is significant need to prioritize programs and services targeting early childhood development in low-and-middle-income countries (LMICs) where 43% of children under the age of five are failing to reach their full developmental potential (Engle et al., 2011). Young children living in poverty in LMICs are exposed to numerous risks, such as undernutrition, infectious diseases, environmental contaminants, and unstimulating surroundings. Exposure to such risks during the first 1,000 days of life – a time-sensitive period in which a child's brain and body are rapidly developing – leads to significant inequalities in a child's developmental trajectory. For example, children who start disadvantaged are more likely to continue to fall behind and are less likely to become educated and productive members of society by adulthood, which perpetuates the cycle of intergenerational poverty (Engle et al., 2007). Thus, the loss of developmental potential comes at a high cost, harming the futures of individual children, as well as the communities in which they live.

Because of its remarkable sensitivity to environmental insults, physical growth is recognized as one of the most informative global indicators of child well-being (de Onis et al., 2000). For example, stunting – a form of undernutrition defined by linear growth failure – is a commonly used indicator for children who are not reaching their developmental potential. Moderate and severe stunting occurs when children's height-for-age Z-score (HAZ) is more than two standard deviations below the population median (UNICEF & WHO, 2012). According to this definition, more than 155 million children under five years are stunted around the globe (UNICEF, 2017). However, this estimate does not account for the millions of other children with borderline growth problems (HAZ > -2.0) who still suffer from inadequate linear growth and, consequently experience compromised outcomes (Prendergast & Humphrey, 2014).

The consequences associated with stunting are costly, and regularly includes death. A severely stunted child is 5.5 times more likely to die before the age of five compared to a non-stunted child (McDonald et al., 2013). Stunting is also associated with impaired cognitive ability (Walker et al., 2015), physical and mental health problems (Nguyen et al., 2014, Hoddinott et al., 2013), fewer years of schooling (Hoddinott et al., 2013, Jensen et al., 2015, Grantham-McGregor et al., 2007), and lower adult earnings (Hoddinott et al., 2013). Furthermore, girls who are stunted are likely to become undernourished mothers who are at a higher risk of having a preterm delivery and/or low-birth weight infants. These infants, in turn, are more likely to die before the age of five or become stunted themselves (WHO, 2015).

Stunting, therefore, is a crucial index of intergenerational poverty and reduced human capital, and finding ways to alleviate the incidence of stunting remains a top public health priority (Prendergast & Humphrey, 2014). Since 1990, the number of stunted children under the age of five has decreased from 253 million to 155 million in 2016 (UNICEF, 2017), in part due to increased global efforts targeting malnutrition. However, the prevalence of stunting remains relatively unchanged in high-burden regions, such as South Asia and sub-Saharan Africa, where child stunting rates remain close to 40-50% (UNICEF, 2017). Though nutrition-specific interventions address the most immediate cause of undernutrition, they have been found insufficient by themselves at supporting optimal growth in children (Dewy & Adu-Afarwuah, 2008). Therefore, to continue the global agenda toward improving nutritional status in children, there is need to go beyond the nutrition sector to tackle other underlying determinants of stunting.

It is becoming increasingly clear that stunting cannot be completely reversed by improving children's diets alone, especially when children live in highly unhygienic environments, as is often the case in the poorest of contexts. The importance of water, sanitation, and hygiene (collectively referred to as 'WASH') has been long recognized as an important public health factor for the health and development of infants and young children (Cumming & Cairncross, 2016). For example, contaminated water, lack of access to or improper use of sanitation facilities, and/or poor hygiene practices increase the risk of children ingesting fecal pathogens – either directly through contaminated hands or indirectly through contaminated drinking water, soil, utensils, food, and flies – which increases the likelihood of infections or diarrheal illness (Mbuya &. Humphrey, 2016). Chronic ingestion of fecal pathogens and frequent infections in early life can cause inflammation and irreversible damage to the gut, impairing a child's ability to properly absorb nutrients, which contributes to stunted growth. Furthermore, as children are introduced to complementary foods, begin crawling and walking on the floor, and continue putting objects in their mouth between six months and two years of age, young children are particularly vulnerable to the negative developmental consequences of poor WASH conditions and fecal pathogen exposure (Ngure et al., 2013).

Increased global attention to and awareness of WASH has led to the dissemination of several behavioral WASH intervention programs around the globe (e.g., Pickering et al., 2015; Strunz et al., 2014). Yet, there have been few WASH behavior programs, which specifically aim to protect young infants and children (Ngure et al., 2013). Due to this critical gap, there have been recent calls for LMICs to implement and scale a package of "child-focused" WASH interventions (also termed "baby-WASH" interventions), which aim to improve caregiver WASH behaviors (e.g., handwashing prior to feeding child, safe disposal of child feces, provision of clean water to children) to create more hygienic environments in which young children can thrive. In response to these calls, the primary goal of the current study was to test the effectiveness of a low-cost, easily scalable child-focused WASH intervention (targeting children ages 0-3) that was delivered to caregivers in Laos, a lower-middle income country in Southeast Asia.

Chapter Overview

In the remainder of this chapter, we: describe the links between WASH and stunting in more detail; provide a theoretical overview of child-focused WASH interventions; and review findings from studies that have implemented child-focused WASH interventions. We also discuss theoretical advantages of combining child-focused WASH interventions with interventions that promote responsive caregiving and stimulation, given that it could be a potential strategy to maximize intervention benefits on child development. At the end of the chapter, we provide an overview of the current study, along with the a priori research aims and hypotheses.

WASH & Stunting

In LMICs, stunted growth usually starts before birth as a consequence of poor maternal nutritional status, and the effects are often exacerbated during the first two years of life due to insufficient nutrient intake and frequent infections, which are typically caused by poor WASH conditions. As observed in Figure 1, the average HAZ among newborns in LMICs is around -0.5 (Victora et al., 2010). Mean height starts to falter at about 3-6 months of age and decline rapidly until reaching a nadir HAZ of approximately -2.0 by 18-24 months of age (Prendergast & Humphrey, 2014; Victora et al., 2010; Shrimpton et al., 2001). This pattern is partially explained by typical feeding practices utilized in the first 24 months of life, but can also be explained by factors related to WASH practices.

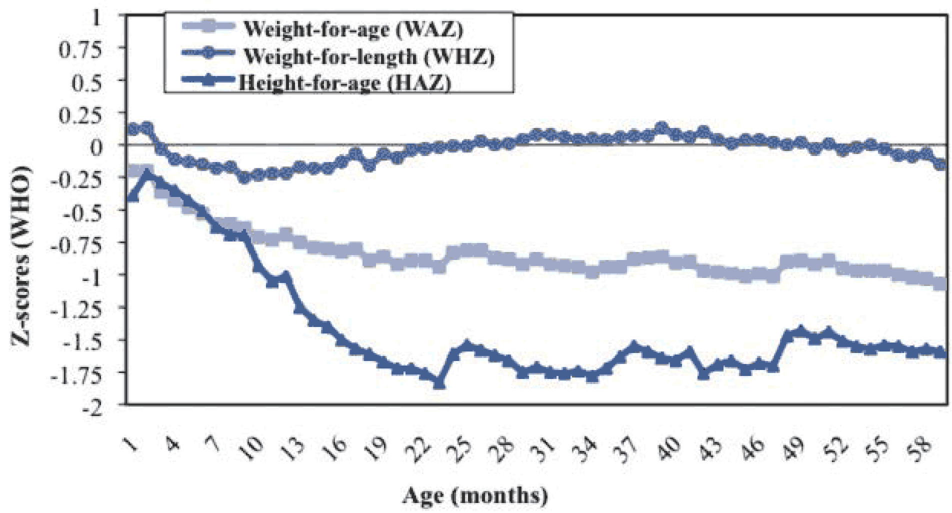


Figure 1. Mean height-for-age Z scores by age (0-59 months) in LMICs (Source: Victora et al., 2010).

Children who are exclusively breastfed during the first six months of life are typically protected from stunting, even when living in unhygienic conditions (Kumar, Goel, Mittal, & Misra, 2006, Kramer & Kakuma, 2002). However, with the introduction of complementary foods and liquids between six-months and two-years of age, young children in LMICs may likely be exposed to infectious and/or parasitic agents in the food or water, resulting in frequent illness (Cumming & Cairncross, 2016). Furthermore, foods, and especially complementary foods in LMICs often are not energy- or nutrient-dense, resulting in long-term insufficient nutrient intake at important points in development (Branca & Ferrari, 2002). In addition, contact with environmental contaminants, such as fecal matter, may also contribute to frequent illness in young children who are crawling on the ground and putting their fingers or objects in their mouths (Ngure et al., 2014).

WASH has been linked to stunting directly through two primary biological pathways: *diarrheal disease* (WHO, 2015) and *environmental enteric dysfunction (EED)* (Humphrey, 2009). Both of these mechanisms are described in detail below.

Diarrheal Disease

Diarrheal disease caused by unsafe drinking water, poor sanitation, and lack of appropriate hygiene is one of the leading causes of mortality and morbidity globally among children under five years (WHO, 2015) and is the number one cause of death in sub-Saharan Africa (Walker et al., 2013). At present, diarrheal disease accounts for approximately 622,000 deaths around the globe each year (WHO, 2015). Among children in LMICs, diarrhea most often results from the ingestion of pathogens from feces that have not been disposed of properly due to inadequate sanitation. In addition, a lack of consistent hygiene practices (i.e., hand-washing, safe food preparation) contributes to the spreading of such pathogens. Figure 2 provides an illustration of how fecal pathogens are likely transmitted from the environment to humans. Young children, in particular, are at a greater risk of pathogen exposure/ingestion if their caregivers fail to engage in adequate household hygiene practices (Ngure et al., 2013, WHO, 2015).

In LMICs, children under five currently experience an average of 2.9 episodes of diarrhea per year, with the most episodes occurring in the first 1,000 days of life (Walker et al., 2012). Frequency of diarrheal disease in the first 1,000 days is strongly correlated with stunting (Checkley et al., 2008, Grantham-McGregor et al., 2007), in part because diarrhea and malnutrition typically co-occur and are mutually reinforcing. For example, diarrheal illness contributes to loss of appetite, malabsorption of nutrients, and increased metabolism – all of which may impact a child's nutritional status (Petri et al., 2008; Dewey & Mayers, 2011). At the same time, undernourished children have weakened immune systems, leaving them more susceptible to infections and more likely to experience frequent and severe bouts of diarrheal illness (Caulfield et al., 2004).

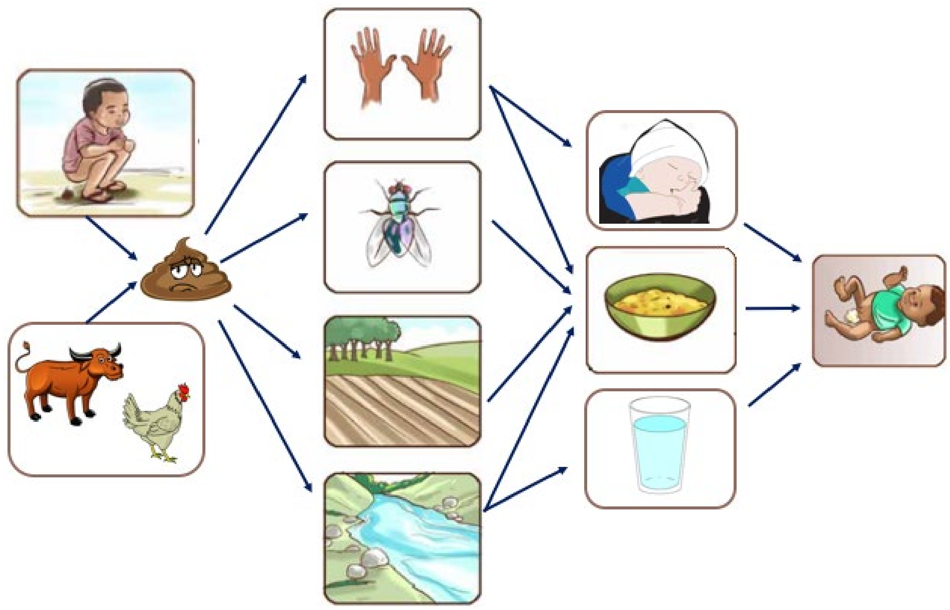


Figure 2. The F-diagram (feces, fingers, flies, field, fluids, food), illustrating the various feco-oral transmission routes that may lead to diarrheal disease (Adapted from Brown, Cairncross, & Ensink, 2013).

Environmental enteric dysfunction (EED)

Environmental enteric dysfunction (EED), also called environmental enteropathy or tropical enteropathy, is a subclinical disorder of the small intestine that occurs among children living in areas with poor sanitation and hygiene (Korpe & Petri, 2012). EED researchers hypothesize that the chronic ingestion of fecal pathogens can cause recurring inflammation and structural damage to the small intestine, leading to a 'leaky' gut and subsequent abnormalities in overall gut function, such as malabsorption of nutrients (Keusch et al., 2014; Mbuya & Humphrey, 2016). EED is hard to detect, however, as affected children do not show overt symptoms like as diarrhea (WHO, 2015). Yet, EED has profound consequences for affected children, including stunted growth, impaired immune functioning, and developmental delays (Korpe & Petri, 2012; Keusch et al., 2014).

It has been argued that EED, rather than diarrhea, may be the primary mediator in the causal pathway between poor WASH and children's growth faltering (Humphrey, 2009). In Bangladesh, for example, one observational study found that children living in households with improved WASH were both less likely to have EED and less likely to be stunted (Lin et al., 2013). Furthermore, EED is also associated with chronic immune activation – that is, when the immune system is constantly stimulated to fight off infection (Cambell, Elia, & Lunn, 2003). Chronic immune activation arising from EED has been associated with poor growth (Cambell et al., 2003) and may also be an underlying cause of other nutritional deficiencies, such as anemia (Weiss & Goodnough, 2005). There is also evidence that poor gut functioning associated with EED may compromise the efficacy of nutritional interventions (Dewey & Adu-Afarwuah, 2008) and oral vaccines (Levine, 2010) among children in LMICs.

Overall, the complex interaction between undernutrition and disease/infection caused by poor WASH conditions can create a vicious cycle of worsening illness and declining nutritional status. The culmination of such factors heightens the risk for early growth faltering and stunting in early life which, unfortunately, is essentially irreversible after the age of two (Stewart et al., 2013; Victora et al., 2010). Therefore, the first few years of life marks a critical window of opportunity during which timely interventions can have a considerable and lasting impact on the prevention of stunting and its consequences, especially in high burden regions where access to adequate WASH and adequate stimulation is particularly poor.

Supporting Healthy Child Development Through WASH Interventions

It is clear that unhealthy environments are linked to child undernutrition, stunting, and associated inequalities in child development. Until recently, WASH was largely overlooked by the global health community as a strategy to address these problems in favor of nutritional interventions and/or early child development interventions. However, in the absence of complementary strategies intended to prevent all aspects of poor WASH, other programs and policies may not be as effective at improving nutritional status in early life in a sustainable way. Therefore, WASH interventions are critical for promoting healthy development in children.

Interventions seeking to interrupt the biological mechanisms that link WASH to stunting should address specific pathways through which feco-oral transmission occurs in the first two years of a child's life. For example, as illustrated in Figure 3, interventions that increased access to safe drinking water, improved sanitation, and appropriate hygiene practices, may prevent undernutrition and stunting in children by interrupting the transmission of fecal pathogens from the environment to humans, thus preventing diarrheal disease and the development of EED (Dangour et al., 2013).

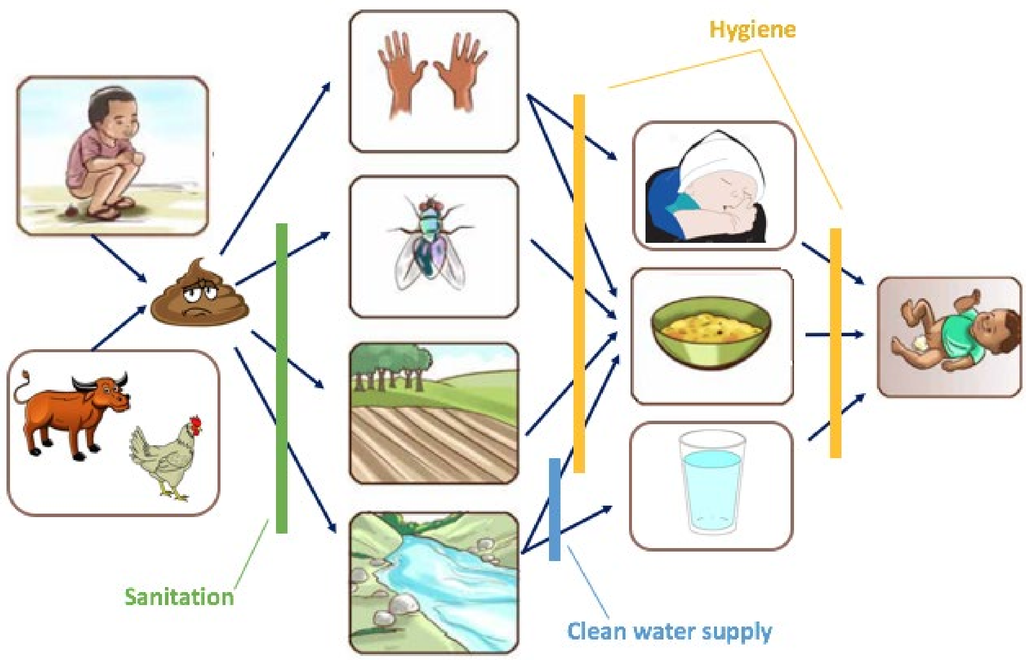


Figure 3. Potential solutions to feco-oral transmission through improved WASH (Adapted from Brown, Cairncross, & Ensink, 2013 and World Bank Group, 2013).

There are several different types of WASH interventions. Some are primarily focused on increasing access to WASH infrastructure through the implementation of: (a) *water quality interventions,* which aim to improve the microbiological quality of drinking water through treatment or safe water storage practices; (b) *water quantity/supply interventions*, which provide a new or improved water supply or improved method of distribution; and (c) *sanitation interventions,* which focus on the construction of new or improved sanitation facilities. In contrast, other interventions that are also considered WASH in nature are more *behaviorally-focused*, such as those that promote a range of WASH behaviors (e.g., appropriate use of improved sanitation, hand-washing practices, soap use, or safe food preparation).

In recent years, there has been greater emphasis on the use of behavioral WASH interventions to maximize the benefits of improved WASH infrastructure (Pruss-Ustun et al., 2014). It has been argued, for example, that without promotion of safe and appropriate WASH behaviors, WASH facilities can be misused or quickly become disused (Souter, 2017). It is estimated that approximately 2.4 million deaths globally (4.2% of all deaths) could be prevented annually if everyone practiced appropriate hygiene and had good, reliable sanitation and drinking water (Prüss-Üstün, Bos, Gore, & Bartram, 2008). In addition, recent estimates suggest that improved access to adequate water and sanitation, in addition to utilizing proper hygiene practices, could prevent 58% of the total diarrheal deaths among children under five around the world (Pruss-Ustun et al., 2014). Specifically, hand washing with soap – an important component of hygiene interventions – has been found to reduce the incidence of child diarrhea by nearly 50% (Curtis & Cairncross, 2003). Increased global attention to and awareness of WASH has led to the dissemination of several behavioral WASH intervention programs around the globe (e.g., Pickering et al., 2015; Strunz et al., 2014). Yet, there have been few WASH behavior programs, which specifically aim to protect young infants and children (Ngure et al., 2013).

Child-Focused WASH Interventions

There have been recent calls for LMICs to implement and scale a package of "child-focused" WASH interventions, which aim to interrupt the specific pathways through which feco-oral transmission occurs in the first two years of life as a central strategy to reduce global stunting rates (e.g., Mbuya & Humphrey, 2016; Ngure et al., 2014, Clean, Fed, and Nurtured Coalition, 2017). There is no singularly agreed on child-focused WASH intervention package, but a general structural framework (summarized in Table 1) has been disseminated by Mbuya & Humphrey (2016) to guide the formulation of relevant interventions or to use as a checklist to ensure that interventions address all relevant pathways through which infants and young children are exposed to and ingest fecal pathogens.

As highlighted in Table 1, child-focused WASH objectives include: (1) reducing the fecal load in the living environment through safe disposal of feces of all household members, including children; (2) reducing fecal transmission via hands through handwashing with soap at key times (i.e., after fecal contact, before handling food/feeding); (3) exclusive breastfeeding in the first six months of life; (4) improving drinking water quality through the treatment of all drinking water; (5) hygienic handling and preparation of complementary foods; and (6) avoidance of child fecal ingestion during mouthing and exploratory play through the use of protective, clean play/feeding areas. Though the primary focus of the child-focused WASH framework is to reduce feco-oral transmission through a package of primarily WASH-related behaviors, this framework also includes recommended actions that overlap with objectives from nutrition and early child development sectors. For instance, the inclusion of hygienic feeding recommendations integrates nutrition sector aims, and the inclusion of using a clean and protective play space integrates early child development sector aims.

Table 1. Structural framework for a package of child-focused WASH interventions to interrupt feco-oral transmission in the first two years of life (adapted from Mbuya & Humphrey, 2016).

Intervention objective	Timing	Behavior Change Messages
Reduce fecal load in living environment	Always	Safe disposal of child feces. Use of sanitary facilities by all household members.
Reduce fecal transmission via hands	Always	Handwashing with soap by all household members (including children) at key times (e.g., after fecal contact, before handling food, and before feeding)
Exclusive breastfeeding	0-6 months	Breastfeeding only; no water or complementary foods unless a non-breastmilk item is needed for prevention or treatment of illness.
Improvement of drinking water quality	After 6 months of exclusive breastfeeding	Drinking of treated water by all household members
Hygienic handling and preparation of complementary foods	After 6 months of exclusive breastfeeding	Hygienic handling and preparation of complementary foods. Provision of freshly prepared foods as much as possible. Fully reheating leftover foods before serving.
Avoidance of child fecal ingestion during mouthing and exploratory play	2-4 months (crawling and mouthing)	Use of a clean play and infant feeding environment, such as a protective play space.

Evidence for Child-Focused WASH Interventions

Although the push for a *comprehensive package* of "child-focused" WASH interventions is a more recent development, there have been several studies that have examined the effects of *individual* child-focused WASH objectives (e.g., handwashing or hygienic food practices only). Most of these studies have been concerned with short-term outcomes related to caregiver hygiene behavior change and observed child health outcomes (i.e., diarrhea), while others, often in combination with nutrition interventions, have focused more on the long-term effects on child growth and development. For instance, the implementation of child-focused WASH interventions targeting child food hygiene in Bangladesh (Islam et al., 2013) and Mali (Touré et al., 2013) have influenced short-term positive hygiene behavior change and reduced amount of fecal bacteria present in children's food. In the Mali study, for example, they trained mothers on handwashing with soap, safe food preparation, reheating leftover foods, and safe food storage (Touré et al., 2013). However, both of these studies were small (30 mothers) and relatively short-term (3 months), and the authors called for larger trials to test feasibility and efficacy at scale.

Increased handwashing with soap among caregivers has frequently been found to reduce diarrheal episodes in young infants and children (e.g., Luby et al., 2006; Wilson et al., 1991; Bhutta et al., 2013). Similarly, drinking water treatment and encouragement of providing children with treated water also has been shown to reduce the frequency of diarrheal episodes in infants and young children (e.g., Luby et al., 2006; Akter & Ali, 2014). However, it is less common for child-focused WASH interventions to produce a measurable short-term effect on child development outcomes, such as cognitive or motor development. However, a recent study found that a handwashing intervention improved children's motor development after one year (Stewart et al., 2018).

Child-focused WASH interventions that attempt to separate animals from child play and feeding areas continue to face significant barriers. For instance, keeping chickens corralled in Peru was found to be ineffective in separating children from contact with chicken feces (Harvey et al., 2003). Barriers to keeping poultry and other livestock corralled at all times includes the commitment and high cost of feeding the animals, building and maintaining corrals, preferring the taste of free-range poultry meat/eggs, and attributing human characteristics to animals (e.g., believing animals want to run, play, and eat food they like) (Harvey et al., 2003, Ngure et al., 2019). There are multiple trials currently testing alternative solutions for reducing direct fecal contact among young children, such as the Sanitation, Hygiene, Infant Nutrition Efficacy (SHINE) trial in Zimbabwe (Humphrey et al., 2015), which promotes the use of protective play/feeding spaces, such as a washable mat or a commercial play yard (a baby-proofed structure, like a playpen, that caregivers can place infants and young children in while doing chores around the household or yard). Preliminary qualitative findings suggest that although caregivers were initially resistant to confining their children to a protective area, parents valued and accepted the use of protective play spaces after they were exposed to messages highlighting the health risks associated with ingesting soil and chicken feces (Mbuya et al., 2015). Similarly, a small observational study (21 caregivers) in Zambia found that a community-built play yard protected infants and young children from ingesting soil and livestock feces (Reid et al., 2018).

Often, child-focused WASH interventions are delivered in combination with nutrition interventions with the goal to more effectively target the underlying causes of child undernutrition and stunting, and thus improve developmental outcomes. For example, the *Alive & Thrive* project in Bangladesh (from 2011-2014, Haque et al., 2012) targeted nutrition and hygiene-related practices that are crucial to the care of children during the complementary feeding period (6-23 months of age), such as infant and young child feeding practices (IYCF), food diversity, handwashing with soap before food preparation and child feeding, and regular maintenance and use of handwashing stations near places of cooking/feeding children. These practices were promoted through small, achievable actions via counseling during routine home visits by volunteers. In addition, some families received free hand-washing stations or materials to create handwashing stations. Although the findings of this study showed significant positive change in caregiver hygiene, IYCF, and developmental outcomes, there were non-differential impacts on child stunting (Menon et al., 2016). Similar patterns of findings have been shown across other studies (e.g., Humphrey et al., 2019).

Overall, there is evidence that child-focused WASH interventions can promote positive caregiver hygiene behavior change, reduce the amount of fecal bacteria in the child's immediate environment, decrease the prevalence of child diarrhea, and impact child development outcomes. However, many of these studies have only targeted one or two single child-focused WASH objectives (i.e., handwashing or food hygiene practices only). Therefore, it seems necessary to examine the feasibility and effectiveness of an intervention which includes a full package of child-focused WASH strategies, as recommend by Mbuya and colleagues (2016). As such, the primary aim of our study was to examine the effectiveness of a child-focused WASH intervention with a more comprehensive set of child-focused WASH targets.

Our review of the current evidence also suggests that, so far, child-focused WASH interventions, alone or in combination with nutrition programming, have not been successful in reducing child stunting. Given that this is a newer area of global interest that is relatively underdeveloped, additional research is needed to better understand how to maximize the effects of child-focused WASH interventions on child development. This may include the possibly of combining child-focused WASH interventions with other important early interventions.

Combined, or "multi-sectoral" approaches, are becoming more widely recognized as a necessary approach to reduce global stunting and inequalities in child development. So far, the most common combinations of integrated interventions include nutrition + child-focused WASH interventions, as well as nutrition + early child development interventions (i.e., those that focus on early childhood stimulation and responsive caregiving behaviors to support brain development). However, to our knowledge, there have not been any studies which have exclusively examined the effects of child-focused WASH interventions when combined with early child development interventions. Given that stunting may mediate the relationship between WASH and early child development (Ngure et al., 2014), there are likely important additive or synergistic benefits from integrating child-focused WASH and early child development programming.

Responsive Stimulation

We know that child survival is attained through a clean and healthy environment and attending to children's nutritional needs. However, evidence suggests that optimal development is achieved through stimulating care (Bornstein & Putnick, 2012). This includes sensitive (i.e., understand a child's cues/signals) and responsive (i.e., respond in a contingent and developmentally appropriate way to these signals) caregiving, as well as opportunities for stimulation through developmentally-appropriate play activities with their child (Yousafzai et al., 2014).

Lack of early learning opportunities and inadequate caregiving behaviors have been shown to contribute to stunting and the loss of developmental potential (Black et al., 2017). For example, caregiver neglect, non-responsive feeding practices, and inadequate stimulation can all interact to impede growth and development (Bégin et al., 1999; WHO, 2012). Furthermore, the interaction between stunting and unresponsive caregiving can create a vicious cycle of worsening nutritional status (Prendergast & Humphrey, 2014). For instance, undernourished children may be fussier or have less energy to explore their environment, which, in turn, may decrease the likelihood that their caregivers will interact with their children or facilitate opportunities for early exploration and learning (Ngure et al., 2014). Unresponsive caregivers may also miss important opportunities to meet their children's needs (i.e., feeding their child when they are hungry), further perpetuating undernutrition and its associated consequences on early development (Prendergast & Humphrey, 2014).

Early interventions aimed at supporting responsive caregiving are effective at improving children's developmental outcomes, especially when delivered in the first 1,000 days (Aboud & Yousafzai, 2015; Britto et al., 2017; Rao et al., 2014). These types of caregiving behaviors often help young children explore and interact with their environment, learn to solve problems, and engage socially and emotionally with others. Importantly, these early benefits also have lifelong effects including improved health and well-being, increased ability to learn, and greater educational and occupational attainment (Boivin et al., 2013; Gertler et al., 2014; Walker, Chang, Vera-Hernández, & Grantham-McGregor, 2011).

There is some evidence that child development benefits are enhanced when responsive stimulation interventions are combined with nutrition interventions (Grantham-McGregor et al., 2014). However, there have been mixed findings on whether responsive stimulation interventions, alone or in combination with nutrition interventions, improve linear growth in young infants and children (Grantham-McGregor et al., 2014). Therefore, there is much more to learn about how to effectively combine interventions to help children reach their full developmental potential.

As mentioned above, no studies have exclusively integrated child-focused WASH interventions with responsive stimulation interventions. This is surprising, given that child-focused WASH and responsive stimulation interventions both target nurturing caregiving behaviors (i.e., those that support healthy child development) as their primary mechanism of change. Therefore, there may be significant advantages to combine WASH with early stimulation programs.

WASH + Responsive Stimulation

It has been hypothesized that stunting resulting from poor gut health and chronic immune activation mediates the causal relationship between poor WASH conditions and deficits in cognitive, motor, and socioemotional development in early childhood (Ngure et al., 2014). Healthy brain development in early childhood requires adequate stimulation acquired through responsive interactions with caregivers and free exploration of the environment (Lozoff et al., 1998). Children living in unhygienic environments who are frequently sick or whose immune systems are chronically activated may have less energy or be more hesitant to initiate interactions with their caregivers or explore their environments (Lozoff et al., 2006). In turn, lower child activity may also decrease the likelihood that caregivers will initiate interactions with their child (Cortés-Moreno, 2017).

Poor physical growth as a consequence of poor WASH may also affect child development through its influence on caregiver behaviors (Levitsky & Barnes, 1972). For example, caregivers may treat children who are small for their age as younger then they actually are, resulting in less appropriate stimulation and therefore altered brain development (Ngure et al. 2014). Additionally, caregivers may not show as much warmth toward their children if they are more irritable or withdrawn due to frequent illness or constant immune stimulation (Ngure et al., 2014).

Given that early stimulation and child-focused WASH programs both focus on aspects of nurturing caregiving practices, there are likely important additive (i.e., when the overall effect of combining the interventions is equal to the sum of what the interventions would have achieved separately) or synergistic (i.e., when the effect is greater than the sum of the effects of the separate interventions) benefits from integrating such programs (Cleary et al., 2012). For example, children who are living in a more hygienic environment are more likely to be healthy and have more energy to initiate and/or engage in stimulating interactions with their caregiver, which may enhance developmental outcomes. Furthermore, the enrichment of sensitive and responsive caregiving behaviors can also protect children's health by helping families to recognize and respond to the early signs of illness. As such, the current study examines whether there are any additive or synergistic effects of a child-focused WASH intervention when delivered in combination with a responsive stimulation intervention to caregivers in Laos.

Lao Context

As one of the poorest countries in Southeast Asia with over half of its children not reaching their full developmental potential, Laos is in dire need of implementing and scaling interventions targeting early child development. Based on the 2016 Human Development Index, a proxy for standard of living based on a country's social and economic status, Laos is ranked in the bottom third at 138 out of 188 countries (UNDP, 2016). Approximately 80% of the population lives in rural areas with poor infrastructure and are reliant on subsistence farming (UNICEF, 2014a), and 16.7% of the population lives below the international poverty line of $1.90 USD a day (UNDP, 2016). The level of formal education is generally low, with an average of 4.5 years for women and 5.6 years for men (UNDP, 2016). Only 29% of women and 49% of men from the poorest quintile are literate (UNICEF, 2014a). Although there are over 49 distinct ethnic groups in Laos, the primary ethnic groups are Lao (53%), Khmu (11%), and Hmong (9%; Lao Statistics Bureau, 2016). Relative to Lao and Hmong ethnic groups, Khmu are at greater risk for infant mortality (Intharack, 2009) and lower socioeconomic status (Vixathep, 2011).

WASH conditions in Lao are relatively poor and underdeveloped. An estimated 37.3% of rural populations in Laos lack access to safe drinking water sources, while 52% lack access to adequate sanitation facilities (UNICEF, 2011).

Children in Laos under the age of five experience an average of three episodes of diarrhea per year, with more episodes occurring in the first two years of life (Midorikaw et al., 2010). It has been estimated that one in ten children in Laos will die from diarrheal disease before their fifth birthday, largely as a result of poor WASH conditions (UNICEF, 2011). And of those that do survive, nearly half will suffer from chronic malnutrition and will fail to reach their full developmental potential (Grantham-McGregor et al., 2007; Lu et al., 2016).

Furthermore, families in Laos also face incredible challenges to providing nurturing conditions for their children due to low economic prioritization of children's health and developmental needs, as less than 1% of Laos' total government expenditures are spent on health (Denboba et al., 2014). Low economic prioritization of children's developmental needs in Laos, combined with inadequate WASH conditions and poor opportunities for adequate stimulation, make it a context in which a child-focused WASH intervention and/or a responsive stimulation intervention may be especially beneficial.

Study Overview

The primary goal of the current study is to document the effectiveness of a low-cost, easily scalable child-focused WASH intervention (targeting children ages 0-3) that was delivered to caregivers in Laos. We examined the effects of the child-focused WASH intervention on caregiver and child outcomes when the intervention was delivered independently, or in combination with an additional low-cost, easily scalable intervention focused on responsive caregiver stimulation. Although the primary focus of the present paper is to document the effects of the child-focused

WASH intervention, we also examined synergistic effects related to the combination of the child-focused WASH and responsive stimulation interventions. A more detailed overview of the responsive stimulation intervention and its effects on caregiving behaviors and child development is provided elsewhere (Fong et al., 2018).

Study Aims & Hypotheses

The current study randomized villages in northern Laos to participate in the WASH intervention and/or the responsive stimulation intervention at the community-level. The child-focused WASH intervention aimed to increase caregiver knowledge around *why* healthy child-focused WASH practices (i.e., caregiver and child hand-washing, safe disposal of child feces, hygienic feeding practices, etc.) are important for their child's health and development, as well as *how* and *when* to use those practices effectively. The responsive stimulation intervention aimed to promote caregivers' sensitivity and responsiveness in the context of developmentally appropriate caregiver-child activities. Villages were randomly assigned to receive a single session of (a) the child-focused WASH intervention, (b) the responsive stimulation intervention, (c) both the child-focused WASH and responsive stimulation interventions, or (d) a control condition. The outcomes of interest included one month post-intervention indicators of caregiver WASH knowledge and self-reported WASH practices, as well as indicators of child health (i.e., occurrence of diarrheal episodes, anthropometric measures) and developmental outcomes (i.e., cognitive and language development). The a priori research aims and hypotheses for the current study included the following:

Aim 1. Assess child-focused WASH intervention acceptability and feasibility. Given that the WASH intervention was designed to be simple and culturally relevant for Lao caregivers, we expected that participants would find the child-focused WASH intervention acceptable in terms of their perceptions that the intervention delivered benefit. We also expected that caregivers would find the intervention feasible in terms of their perceptions that they would be able to adopt the recommended practices.

Aim 2. Examine effects of the child-focused WASH intervention on indicators of caregiver knowledge and practices. Because the WASH intervention aimed to teach caregivers about why WASH is important for child health and development, as well as how to engage in child-focused WASH behaviors, we hypothesized that caregivers randomized to receive the child-focused WASH intervention would show increases on indicators of WASH-related knowledge and practices at one month post-intervention, relative to caregivers who did not receive the child-focused WASH intervention. Given that the WASH and responsive stimulation interventions both target nurturing caregiving practices that support healthy child development, we expected caregivers who received both interventions may have become more attuned to the needs of their children. As such, we also hypothesized that we would find an additive or synergistic effect for the combined WASH + responsive stimulation group, in that this group would show even greater increases on indicators of WASH knowledge and practices at one month post-intervention.

Aim 3. Examine intervention effects on indicators of child health and developmental outcomes. Given that the WASH intervention specifically focuses on promoting child health and development through caregiver behaviors, we hypothesized that children of caregivers randomized to receive the child-focused WASH intervention would experience positive health and developmental outcomes, including decreased likelihood of diarrheal episodes and higher cognitive/language development scores at one month post-intervention compared to children whose caregivers did not receive the WASH intervention. We also hypothesized that we would find an additive or synergistic effect for the combined WASH + responsive stimulation group, in that children in the combined group would experience the best outcomes (i.e., lowest likelihood of experiencing diarrheal episodes post-intervention; greater increases on cognitive/language development scores), relative to the other groups. We did not expect to observe significant differences in anthropometric measurements (i.e., standardized height and weight scores) at one month post-intervention among children whose caregivers received the child-focused WASH intervention, given the short duration of this study.

CHAPTER II

METHOD

This chapter contains unpublished co-authored material. M. Fong, C. Lattanavong, O. Inthachith, and J. Measelle contributed substantially to the study and procedures described in this chapter. I designed the study with M. Fong. Data collection was organized by C. Lattanavang and O. Inthachith. M. Fong took the lead on designing and overseeing the responsive stimulation intervention described in this chapter. I took the lead on designing and overseeing the WASH intervention described in this chapter. I wrote this chapter with editorial assistance from J. Measelle. I also received statistical consultation from J. Seeley and D. Baldwin.

Participants

Participants were 145 children (49.7% girls) and their primary caregivers (88.3% mothers) who were enrolled in the study when the child was between birth and 60 months of age (M = 20.44 months, SD = 12.49). At baseline, the mean age of caregivers was 27.19 years (SD = 7.03). Most caregivers had completed a primary (33.1%) or secondary (36.6%) level of education, while a smaller number reported completing a higher than secondary level of education (16.6%) or no schooling at all (13.1%). The average number of children per family was 4.15 (SD = 1.15). Participants resided in small rural villages within the predominantly agricultural Pak Ou District of the Luang Prabang Province in northern Laos. Cash crops and subsistence farming were the primary source of livelihood for the majority (89.6%)

of the sample. The ethnicity of most participants was Khmu (61.1%), followed by Hmong (25.0%) and Lao (13.8%). A summary of these sample characteristics is provided in Table 2 (caregiver characteristics) and Table 3 (child characteristics).

A total of 144 (99.3%) families completed the one-month post-intervention assessment. One family (from Village B) moved out of the village prior to the one-month post intervention assessment.

Procedures

Due to governmental restrictions in Laos[1], villages were unable to be selected at random. Rather, villages were selected by government officials with assistance from our partners from VolunTour Laos (VTL), a local Lao non-governmental organization (NGO) that promotes sustainable community development through the construction of improved water and sanitation infrastructure. Villages were selected from a large pool of villages (>30) that had previously engaged in WASH infrastructure development projects with VTL. Four villages were selected based on location (i.e., within the Pak Ou District), accessibility (i.e., if the village was accessible by car), and whether the village had at least 30 families with children under the age of five. All selected villages had community-level access to improved sanitation and piped water systems. In each of these four villages, families were invited to participate in the study if they had at least one child under the age of five years (with preference given to children under

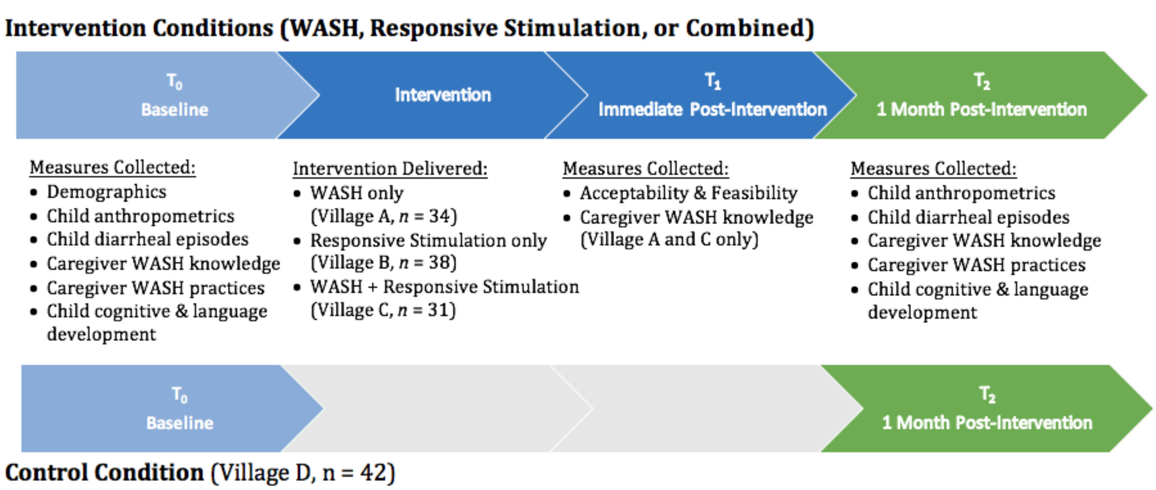
[1] Laos is a small communist nation whose constitutional and legal system is still underdeveloped. There are currently several governmental restrictions on NGO and community development work, which present significant barriers for implementing or evaluating new policies and programs (Hale, 2014).

the age of three). Each village was randomly assigned to one of four conditions. Village A was randomly assigned to receive the child-focused WASH intervention only (n = 34); Village B was randomly assigned to receive a responsive stimulation intervention only (n = 38); Village C was randomly assigned to receive both the child-focused WASH intervention and a responsive stimulation intervention (n = 31); and Village D was randomly assigned to the control condition where they did not receive either intervention (n = 42). For simplicity, we will refer to the child-focused WASH intervention as the "WASH intervention" throughout the remainder of this paper.

All contact with study participants was made in the local language/dialect (Khmu, Hmong, or Lao) by trained health workers, or through the aid of an interpreter. Similarly, all data collection materials were translated and delivered in the local language/dialect by the health workers, or through the aid of an interpreter. All caregivers were over the age of 18, provided informed consent, and could refuse to participate at any time. Ethics approval for this study was obtained from the University of Oregon institutional review board (Protocol 04292016.050). Local governmental clearance for this study was obtained through the Lao Ministry of Health and the Lao Ministry of Tourism with assistance from VTL.

Trained Lao health workers traveled to each village and collected child anthropometric measurements and survey data from all study participants. All data was collected via electronic tablets through one-on-one interviews with caregivers. As illustrated in Figure 4, all study participants were assessed at baseline (T_0) using an identical set of measures (which are described in detail later in this section).

Baseline assessments took approximately 30 minutes per participant, and it took the assessment team two full work days to complete all baseline assessments within each village. On the day following completion of baseline assessments, participants from Village A (WASH only), Village B (Responsive Stimulation only), and Village C (WASH + Responsive Stimulation) received their respective assigned intervention(s). Interventions were delivered to participants by the trained Lao health workers. Each intervention took approximately one hour and was delivered in a large group setting, usually in the village's town hall. Survey data was collected from participants immediately following delivery of the intervention(s) (T_1). T_1 assessments took approximately 5 minutes per participant. Participants in Village D (control condition) did not receive an intervention or complete the T_1 assessment. All study participants were re-assessed one month after receiving the intervention



(T_2) using the same set of measures from the baseline assessment.

Figure 4. Overview of procedures

Conditions

WASH Intervention (Village A): Trained Lao health workers implemented the WASH intervention to all participating caregivers as a group. The one hour WASH program aimed to teach caregivers two key lessons: 1) *why do children get diarrhea?* (in other words, what are the feco-oral transmission routes that lead to disease?), and 2) *how can you prevent your child from getting diarrhea?* (in other words, what child-focused WASH behaviors will help prevent the feco-oral transmission of disease?) The WASH intervention was designed by our team using several evidence-based principles and components, which are described below.

In alignment with Mbuya and colleagues' (2016) recommended child-focused WASH framework, key behavior change messages in the WASH intervention included: safe disposal of child feces, handwashing with soap by caregivers and children at key times (e.g., after fecal contact, before handling food, and before feeding), drinking of treated water, and hygienic food practices (e.g., fully reheating leftover foods, washing fruits/vegetables, covering leftovers, washing dishes and utensils). The intervention also touched on exclusive breastfeeding and the use of a protected play and infant feeding environments, such as a washable mat, though these were not primary behavior change targets of the intervention. Each caregiver received a single-page WASH counseling card (see Figure 5), which they got to take home, that summarized the key program messages. The counseling card was designed to be culturally-relevant (i.e., illustrations depicted Lao families and WASH infrastructure relevant for the context, such as latrines and handwashing stations)

Figure 5. English version of the WASH intervention counseling card given to caregivers to take home. This card illustrates four categories of child-focused WASH behaviors that parents can engage in to protect their children from feco-oral transmission. The cards are simple, colorful, and have minimal text to ensure that all caregivers are easily able to comprehend the program messages.

and simple with minimal text to ensure that all caregivers were easily able to comprehend the primary program messages (Yousafzai & Aboud, 2014).

The WASH intervention emphasized the importance of promoting child health, growth, and intelligence, given prior evidence that caregivers highly value these child qualities (Humphrey et al., 2015). For example, health workers conveyed messages, such as: "regular handwashing with soap at critical times will help your child grow up to be bigger and stronger" or "clean drinking water will help your child stay healthy, which will help your child do better in school." Furthermore, the primary text on the WASH counseling card described the recommended behaviors as “four ways to keep your child healthy” and included an image of a young child posing as healthy and strong (See Figure 5).

The lessons within the WASH intervention were informed by principles of adult learning, such as using visual aids and interactive puzzles and activities (Knowles, 1980). For example, to help caregivers learn about the various feco-oral transmission routes that lead to child disease, the health workers used guided questions and visual aids to help caregivers construct the F-diagram (see Figure 2) together as a group. To help consolidate learning (Gijbels & Dochy, 2006), caregivers also participated in a group problem-solving game. In this activity, caregivers were shown a series of pictures of children encountering fecal bacteria in various ways. For each picture, caregivers were asked: (a) “what is wrong with this picture?”; (b) “where are the germs?”; (c) “how do we protect the child?” For example, one of the pictures from this activity showed a child sitting down to eat a meal immediately after playing outside barefoot in the dirt (see Figure 6). Caregivers were asked to (a) name the errors of this picture (i.e., “the child did not wash his hands/feet before eating”), (b) identify where the germs were located by placing the “germ card” on the picture in the correct location (i.e., in the dirt; on the child’s hands/feet), and then (c) identify ways to protect the child by placing an appropriate “WASH behavior card” on the picture in the correct location (i.e., washing the child’s hands before eating; washing the child’s feet after play).

Figure 6. An example of the "correct the picture" activity in the child-focused WASH intervention.

The WASH intervention also included a brief handwashing demonstration. Handwashing demonstrations have shown to be an effective part of reducing childhood diarrhea incidence (Hashi, Kumie, & Gasana, 2017). Specifically, the health workers showed caregivers how to wet their hands, lather them completely with soap, and rub them together for one minute. Based on methods for behavior change (Aboud & Akhter, 2011), caregivers practiced this activity during the intervention to gain confidence and encourage changes in their behavior. Each caregiver also received a bar of soap to take home.

The WASH intervention included other strategies to promote effective behavior change. Commitment making, for instance, is commonly regarded as an effective way to promote behavior change (Lokhorst et al., 2011). At the end of the WASH intervention, health workers asked caregivers to set realistic goals and make a verbal commitment to trying to implement one more child-focused WASH behavior. For example, a caregiver might set a goal to wash her hands before preparing her child's food and commit to trying to do it the next time she prepares a meal. Health workers also helped caregivers identify anticipated obstacles for change and then problem-solve possible coping strategies or solutions, another effective technique for promoting behavior change (Kwasnicka et al., 2013). For example, if a caregiver did not have frequent or reliable access to improved sanitation, health workers could help the caregiver identify an alternative solution, such as burying feces at least 10 meters away from a water source.

Responsive Stimulation Intervention (Village B): Trained Lao health workers implemented a responsive stimulation intervention, specifically UNICEF and WHO's (2012) Care for Child Development (CCD), to all participating caregivers in a group setting. This one hour program, specifically adapted for use in Laos (see Fong et al., 2018), aimed to build stronger relationships between caregivers and children through responsive and nurturing caregiving, which included sensitivity to children's movements, sounds and gestures, and interpreting and responding appropriately to them. Responsive caregiving is the basis for protecting children against injury, recognizing and responding to illness, enriching learning, and building trust and social relationships (Ainsworth et al., 1974).

During the responsive stimulation intervention, health workers demonstrated developmentally appropriate play and communication activities for caregivers and asked them to practice with their child in the session to boost caregiver's confidence to encourage behavior change (Aboud & Akhter, 2011). Health workers provided immediate feedback to enhance the quality of caregiver-child interactions (Lucas, Richter, & Daelmans, 2017). Examples of developmentally appropriate play and communication activities include playing "peek-a-boo" with a six-month-old or practicing counting with small objects (i.e., stones) with a two-year-old. These activities promote strong emotional bonds between caregivers and children, enabling caregivers to stimulate motor, cognitive, social and emotional learning in children (Lucas, Richter, & Daelmans, 2017). Each caregiver received a responsive stimulation counseling card (see Figure 7) that summarized the recommended play and communication activities, which were organized by age group. The activities are designed to be simple and feasible for caregivers in low economic contexts. For example, the activities do not require caregivers to purchase toys. Rather, the intervention directs caregivers to use common household objects (i.e., spoons, bowls, pots) as toys (Lucas et al., 2017).

There were several similarities between delivery components of the responsive stimulation intervention and the WASH intervention. First, the responsive stimulation intervention also emphasized the importance of caregiver stimulation for promoting child health, growth, and intelligence to encourage caregiver engagement (Humphrey et al., 2015). For example, health workers conveyed messages, such as "playing and communicating regularly with your child will help your child learn and be a better student in school." Furthermore, the heading on the counseling card directly states, "Play and talk with your child for healthy development."

Figure 7. English version of the responsive stimulation intervention counseling card. Recommended play and communication activities are divided into age bands to help caregivers easily identify activities that are developmentally appropriate for their child. The cards are simple, colorful, and have minimal text to ensure that all caregivers are easily able to comprehend the program messages.

Also similar to the WASH intervention, caregivers in the responsive stimulation intervention were asked to set realistic goals and make a commitment to trying to implement new behaviors, such as a mother setting a goal to play "peek-a-boo" with her child and committing to doing it after the child wakes up from his next nap. The health workers also helped caregivers problem-solve around anticipated obstacles for change. For example, if a caregiver was concerned about not having any toys for their child to play with, the health workers suggested alternative household objects that could safely be used as toys.

CCD has been implemented in 19 countries, including Brazil, South Africa, Turkey, rural China, Pakistan, Tajikistan, Kazakhstan, and Kyrgyzstan (Richter et al,, 2017). Studies have consistently demonstrated higher cognitive, language, and motor development among children who had received the CCD intervention in the first two years of life (e.g., Yousafzai et al., 2014; Engle, Smeby, & Grover, 2011; Lucas et al. 2017). Studies in Turkey (Ertem et al., 2006) and Brazil (dos Santos et al., 1999) found that caregivers who received the CCD intervention engaged in more play and communication activities, remembered health worker messages, and had more childcare skills. Furthermore, findings from previous studies support the short-term efficacy of single sessions of CCD ranging from seven to sixty minutes in session length (Ertem et al., 2006; Jin et al., 2007). There is also evidence for the short-term efficacy of a higher dosage of CCD comprising monthly sessions over the course a child's first two years of life (Yousafzai et al., 2014). Overall, CCD has been shown to be an effective intervention to increase caregiver responsiveness and cognitive stimulation.

WASH Intervention + Responsive Stimulation (Village C): Caregivers in Village C received both the WASH and responsive stimulation interventions. First, health workers delivered the one-hour responsive stimulation to participating caregivers in a group setting. Then, following a 30-minute intermission, health workers delivered the one-hour WASH intervention. The program content for the WASH intervention and the responsive stimulation intervention was identical to what was described above for Villages A and B, respectively.

Control Condition (Village D): Caregivers in the control condition did not receive either of the interventions described above.

Fidelity of Intervention Implementation

Lao health workers were trained to implement the WASH and responsive stimulation interventions to fidelity. They were trained in English, so that the primary investigators (Wright and Fong) could directly assess whether the health workers knew and understood the intervention material. The health workers were provided with an illustrated outline/script to use during the delivery of each intervention to ensure that all intervention components were delivered and in the correct order. The health workers practiced administering the interventions to the primary investigators in English until the health workers were reliable and the interventions were delivered to 100% fidelity. Once reliable, the health workers were videotaped delivering the intervention to multiple groups of Lao families across several practice villages. Afterwards, the health workers and primary investigators reviewed tapes together to assess the fidelity of implementation. Data collection began after health workers could reliably deliver interventions to 100% fidelity. Intervention delivery during official data collection was videotaped and monitored for fidelity.

Measures

Acceptability and Feasibility of the WASH Intervention. Seven items were used to assess the acceptability and feasibility of the WASH intervention immediately following intervention delivery (T_1) in terms of caregivers' perceptions of (a) whether or not the health worker was clear and easy to understand during the presentation of the program; (b) whether or not the program was useful; (c) whether or not the counseling card was useful; (d) whether or not the program was helpful for their child; (e) whether or not the program benefited the caregiver; (f) whether or not they believed the recommended program actions would be difficult to put into practice; and (g) whether or not they would recommend the program to other families. Response options were dichotomous (yes/no). Although developed specifically for our study, these items were based on program acceptability and feasibility measures used in a similar intervention study (Roesner et al., 2013).

Child anthropometrics. Child height and weight were assessed at baseline (T_0) and a one-month follow-up (T_2). Child height was obtained with a measuring tape using the average of three measures of child length (in centimeters) obtained by the same observer. Child weight was obtained in kilograms using a digital scale. For children under the age of 24 months, weights were obtained for the caregiver alone and with the caregiver holding the child. The child's weight was recorded as the difference between those two weights. Children over the age of 24 months were weighed independently.

Z-scores were generated for child height-for-age (HAZ), weight-for-height (WHZ), and weight-for-age (WAZ) using the World Health Organization growth standards (WHO, 2014b). Stunting was coded as 1 (stunted) if a child's HAZ was < -2.0, and 0 (not stunted) if HAZ was ≥ -2.0. Wasting was coded as 1 (wasted) if a child's WHZ was < -2.0, and 0 (not wasted) if WHZ was ≥ -2.0. Clinically underweight was coded as 1 (clinically underweight) if a child's WAZ was < -2.0, and 0 (not clinically underweight) if WAZ was ≥ -2.0. This stratification method is widely accepted in research examining determinants of childhood stunting and wasting (e.g., Martorell & Young, 2012; Checkley et al., 2008; and Rayhan & Khan, 2006).

Child diarrheal episodes. Data about child diarrheal episodes was collected via caregiver report at baseline (T_0) and one-month post-intervention (T_2) using relevant items from UNICEF's Multiple Indicator Cluster Survey (MICS) 4 (2012). At baseline, caregivers answered questions about their child's history of diarrhea (if relevant), including how often their children had a diarrheal episode (e.g., 1-2 times per year, 3-4 times per year, etc.), the length of the longest past diarrheal episode (in days), and where the child was usually treated for diarrhea (e.g., hospital, clinic, at home). The child diarrheal outcome variable of interest measured whether a diarrheal episode had or had not occurred within the past month. This variable was dichotomous (yes/no).

Cognitive and language development. Children's cognitive and language development was assessed at baseline (T_0) and one month post-intervention (T_2) using the cognitive and language subscales of the Caregiver Reported Early Child Development Index (CREDI; McCoy et al., 2018). The CREDI is a low-cost measure of motor, cognitive, and socioemotional development in children under five that was specifically designed to be used in low-resource contexts. The CREDI uses caregiver report, rather than direct assessment, of child development skills to acquire a more generalizable perspective on children's skills and behaviors across time and settings. Direct assessments of cognitive assessment are more likely to be biased against children in low-resource settings, as these children are less likely to be familiar with clinical assessments or following verbal instructions (Snow & Hemel, 2008).

The CREDI was designed to be a) simple and clear enough to be answered by a caregiver with minimal formal education, (b) short enough to be feasibly integrated within large-sample household data collection efforts, (c) "culturally neutral" to allow for cross-context comparison, and (d) adequately aligned with "gold standard" direct assessments of child development (McCoy et al., 2018). The CREDI has been tested in more than 15 low- and middle-income countries, including Laos (McCoy et al., 2018), and has demonstrated adequate levels of acceptability, internal consistency, and validity (McCoy et al., 2017). The 0 to 12 month (22 items), 13 to 24 month (31 items), and 25 months and older (30 items) versions were used in the current study. For each item, caregivers responded "no" (0) or "yes" (1) to questions about their children's cognitive and language abilities. Example of items included: "Can the child make simple sounds like ba-ba-ba or da-da-da?" or "Does the child know the name of at least two body parts?" Cognitive and language development factor scores and norm-referenced standardized scores (z-scores) were generated for each child using the *credi* package in R (McCoy et al., 2018).

Caregiver WASH Knowledge. Caregiver WASH knowledge was assessed at baseline (T_0) and one-month post-intervention (T_2). Caregivers in Villages A and C who received the WASH intervention were also assessed immediately following the delivery of the intervention (at T_1). Caregivers were asked to provide as many responses as possible to two open-ended questions: (1) "*Why do children get diarrhea*?" (assessing knowledge around feco-oral transmission routes that lead to disease), and (2), "*How do you protect children from getting diarrhea*? (assessing knowledge around how to prevent feco-oral transmission of disease). Correct responses were scored as "1." Sub-scores for "causes of diarrhea" and "prevention of diarrhea" knowledge were calculated from the sum of correct responses for each question, with higher scores indicating greater WASH knowledge in that area. "Causes of diarrhea" knowledge scores ranged from 0 to 6, and "prevention of diarrhea" knowledge scores ranged from 0 to 10. A total Caregiver WASH Knowledge score was calculated from the sum of the two knowledge sub-scores (α = .73). Total scores ranged from 0 to 16, with higher scores indicating greater overall WASH knowledge. This measurement strategy was based upon a previous study done in Bangladesh, which measured participant health knowledge around the transmission and prevention of HIV/AIDS (Do & Kincaid, 2006).

Caregiver WASH Practices. Caregivers' self-reported WASH practices were assessed at baseline (T_0) and one month post-intervention (T_2). Caregivers were asked questions about how often they engaged in a child-focused WASH behavior. Caregivers responded to each question using a Likert scale of 0 (never) to 4 (always). Five key child-focused WASH practices (Mbuya et al., 2016) were assessed: (a) proper disposal of child feces, (b) handwashing after child defecation, (c) caregiver handwashing prior to feeding/preparing food, (d) washing the child's hands prior to feeding/eating, and (e) giving the child adequately treated drinking water. Caregivers were only asked questions relevant for their child's developmental stage (i.e., depending upon if the child is still breastfeeding, eating complementary foods, or is toilet-trained). See Table 2 for the complete list of WASH practices questions and their corresponding developmental stage. Sub-scores for each of the five WASH practice areas were calculated using the average score of each area's respective question(s). An overall Caregiver WASH Practice score was calculated by taking the average of the five area sub-scores (α = .70). Higher scores reflect more frequent self-reported use of caregiver WASH practices. This measurement strategy is similar to those used in other studies that have examined self-reported hygiene behaviors (e.g., Rabbi & Dey, 2013; Biran et al., 2008; El-Gilany, Badawi, & Fedawy, 2005).

Table 2
Caregiver WASH Practices Questions

WASH Practice Area Assessed	Question(s) asked	Developmentally relevant for
(a) Proper disposal of child feces	Q1. How often do you dispose of your child's feces in the toilet?	Q1. Infants; children who are not fully toilet-trained
	Q2. How often do you direct your child to defecate in the toilet?	Q2. Children who are toilet-training or are toilet-trained.
(b) Handwashing after child defecation	Q3. How often do you wash your own hands with soap after handling your child's feces?	Q3. Infants; children who are not fully toilet-trained
	Q4. How often do you wash your child's hands (or direct your child to wash his/her hands) with soap after defecation?	Q4. Children who are toilet-training or are toilet-trained
(c) Caregiver handwashing prior to feeding/preparing food	Q5. How often do you wash your own hands with soap before breastfeeding?	Q5. Infants and children who are still breastfeeding
	Q6. How often do you wash your own hands with soap before preparing food for your child?	Q6. Infants and children who are eating complementary foods
(d) Washing the child's hands prior to feeding/eating	Q7. How often do you wash your child's hands with soap before the child breastfeeds?	Q7. Infants and children who are still breastfeeding
	Q8. How often do you wash your child's hands (or direct your child to wash his/her hands) with soap before eating?	Q8. Infants and children who are eating complementary foods
(e) Giving the child adequately treated water	Q9. How often do you give your child adequately treated drinking water?	Q9. Infants and children who are not exclusively breastfeeding. [a]

Note: Response options for each question included: "never" (0), "rarely" (1), "sometimes" (2), "mostly" (3), and "always" (4). [a] Caregivers who were exclusively breastfeeding (11.1%) were excluded from Q9.

Sociodemographic variables. The following sociodemographic variables were assessed by caregiver self-report at baseline: (a) child age, (b) child gender, (c) caregiver gender, (d) caregiver's highest level of education completed, (e) ethnicity, and (g) family size as indexed by the total number of children in the household. We did not have a direct measure of socioeconomic status. However, because education correlates strongly with socioeconomic status in Lao PDR (LSIS, 2011-2012), we used maternal education as a proxy for socioeconomic status.

Statistical Analyses

A power analysis specific to a 2x2 factorial design using the computer application G*Power (Faul et al., 2013) indicated that a sample size of 145 would achieve 76% power (with alpha at .05) to detect a statistically significant difference with a medium effect size at one month post-intervention (T_2). A total of 179 participants would have been required to achieve 80% power with alpha at .05.

Analyses were conducted in SPSS version 25 using an intention-to-treat (ITT) design. First, we looked at descriptive statistics of demographic and baseline characteristics, overall and by intervention condition. Using ANOVA tests for continuous variables and chi-square tests for categorical variables, we assessed similarities between intervention groups and identified potential confounders to be used as covariates in subsequent analyses. Second, we used multiple imputations (MI) assuming data missing at random to impute missing values for outcome variables to obtain a complete data set for all time points. The MI was implemented in R using the multivariate imputation by changed equations (MICE) package (Robitzsh, Grund, & Henke, 2019). Next, paired-samples t-tests were used to compare caregiver WASH knowledge scores between T_0 and T_1 (manipulation check of the intervention) and between T_0 and T_2 (maintenance effects of the intervention) among caregivers who received the WASH intervention (i.e., Villages A and C).

For the primary statistical analyses, we performed a series of 2x2 factorial analysis of covariance models (ANCOVAs) to compare each continuous outcome variable (i.e., caregiver WASH knowledge, caregiver WASH practices, child anthropometrics, and child cognitive/language development) across intervention conditions (WASH vs. no WASH; Responsive Stimulation vs. no Responsive Stimulation) at T_2 after adjusting for baseline (T_0) values of the outcome variable. We then repeated the ANCOVA analysis to adjust for possible confounding variables. See Figure 8 for an illustration of the 2x2 factorial design. For our non-continuous outcome variable (child diarrhea at T_2), we used a binomial logistic regression to examine the association between intervention group and whether or not the child had experienced a diarrheal episode in the past month (yes/no). We also included possible confounding variables in the model.

WASH Intervention

Responsive Stimulation (RS) Intervention		**WASH**	**No WASH**	Totals
	RS	**WASH + RS (Village C)** n = 34	**RS only (Village B)** n = 38	72
	No RS	**WASH Only (Village A)** n = 31	**Control (Village D)** n = 42	73
	Totals	65	80	145

Figure 8. 2x2 factorial design

CHAPTER III

RESULTS

This chapter contains unpublished co-authored material. M. Fong, C. Lattanavong, O. Inthachith, and J. Measelle contributed substantially to the study and findings described in this chapter. I designed the study with M. Fong. Data collection was organized by C. Lattanavang and O. Inthachith. M. Fong took the lead on designing and overseeing the responsive stimulation intervention described in this chapter. I took the lead on designing and overseeing the WASH intervention described in this chapter. I analyzed the data and wrote this chapter with input and editorial assistance from J. Measelle. I also received statistical consultation from J. Seeley and D. Baldwin.

Baseline Data and Bivariate Correlations

Descriptive statistics for sample characteristics of caregivers and children at baseline are displayed in Tables 3 and 4, respectively. At baseline, there were significant differences between villages on child age ($F(3, 141) = 6.44$, $p < .001$), caregiver age ($F(3, 141) = 6.00$, $p = .001$), ethnicity ($\chi^2(9) = 79.82$, $p < .001$), and education level ($\chi^2(12) = 74.37$, $p < .001$). For example, children tended to be older in Village A ($M = 26.62$ months, $SD = 12.59$) and Village C ($M = 23.33$ months, $SD = 12.50$), compared to children in Village B ($M = 15.56$ months, $SD = 10.19$) and Village D ($M = 17.80$, $SD = 12.10$). Similarly, caregivers tended to be older in Village A ($M = 30.07$ years, $SD = 9.08$) and Village C ($M = 29.48$ years, $SD = 6.76$), compared to caregivers in Village B (*M* = 24.94 years, *SD* = 5.86) or Village D (*M* = 25.27 years, *SD* = 4.82). The majority of families from Village B (97.4%) were Khmu, while the remaining villages were more ethnically diverse. Specifically, 58.8% of families in Village A were Khmu (41.2% Lao); 54.8% of families in Village C were Hmong (35.5% Khmu and 9.7% Lao); and 50.0% of families in Village D were Khmu (45.2% Hmong and 4.8% Lao). Caregivers in Villages B and C tended to be more highly educated, with 92.2% of caregivers in Village B and 70.9% of caregivers in Village C having had completed at least a secondary level of education. In comparison, 41.2% of caregivers in Village A had completed only a primary level of education (14.7% had no formal education), and 64.3% of caregivers in Village D had only completed a primary level of education (23.8% had no formal education). We controlled for these sociodemographic variables in our analyses.

There were also baseline differences between villages on caregiver WASH knowledge ($F(3, 141) = 10.16$, $p < .001$), caregiver WASH practices ($F(3, 141) = 5.26$, $p = .002$), child cognitive development z-scores ($F(3, 141) = 4.64$, $p = .004$), and child language development z-scores ($F(3, 141) = 5.59$, $p = .001$). Specifically, baseline WASH knowledge scores were highest among caregivers in Village C (*M* = 10.16, *SD* = 1.68) relative to the other villages (Village A: *M* = 7.88, SD = 1.65; Village B: M = 7.79, *SD* = 1.28; Village C: *M* = 8.36, *SD* = 2.76). Baseline WASH practice scores were highest among caregivers in Village A (*M* = 1.80, *SD* = 1.11) relative to the other villages (Village B: *M* = 1.37, SD = 0.52); Village C: M = 1.14, *SD* = 0.39); Village D: *M* = 1.33, *SD* = 0.53). Child cognitive development z-scores were highest among caregivers in Village A (*M* = -0.34, *SD* = 1.80) relative to the other villages (Village B:

M = -1.54*,* SD = 1.05); Village C: M = -1.77*, SD* = 0.89); Village D: *M* = -1.32*, SD* = 0.21). Child language development z-scores were also highest among caregivers in Village A (*M* = -0.21, *SD* = 1.66) relative to the other villages (Village B: *M* = -1.13*,* SD = 1.18); Village C: M = -1.28*, SD* = 0.99); Village D: *M* = -1.11*, SD* = 0.21). There were no other significant differences between groups on any other baseline measures or sociodemographic variables ($p > .05$).

Bivariate correlations among all study variables can be found in Table 5. Exposure to the WASH intervention was associated with greater caregiver WASH knowledge and more frequent self-reported caregiver WASH practices at one-month post-intervention (T_2). Exposure to the WASH intervention was also associated with higher child language development scores at one-month post-intervention. At baseline, caregivers' WASH practices scores were positively associated with child age. Child age was also positively associated with child cognitive and language development scores, as well as WAZ and WHZ scores at baseline and one-month post-intervention. Identifying as Khmu, as well as having higher than a secondary level of education, were both associated with fewer children in the home. At baseline, identifying as Hmong was associated with greater caregiver WASH knowledge, but also less frequent self-reported caregiver WASH practices. Identifying as Hmong was also associated with lower child cognitive and language development scores, as well as lower HAZ and WAZ scores, at baseline and one-month post-intervention.

Table 3

Baseline (T_0) Characteristics of Caregivers by Village

	Total Sample (n = 145)		Village A: WASH (*n* = 34)		Village B: Stimulation (*n* = 38)		Village C: WASH + Stimulation (*n* = 31)		Village D: Control (*n* = 42)	
Caregiver Sample Characteristics	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)
Caregiver Age (years)	27.19	(7.03)	30.07	(9.08)	24.94	(5.86)	29.48	(6.76)	25.27	(4.82)
Female gender	128	(88.3%)	29	(85.3%)	31	(81.6%)	29	(93.5%)	39	(92.9%)
Education Completed										
None	19	(13.1%)	5	(14.7%)	1	(2.6%)	3	(9.7%)	10	(23.8%)
Primary school	48	(33.1%)	14	(41.2%)	2	(5.3%)	6	(19.4%)	27	(64.3%)
Secondary school	53	(36.6%)	14	(41.2%)	27	(71.1%)	9	(29.0%)	3	(7.1%)
Higher than secondary school	24	(16.6%)	1	(2.9%)	8	(21.1%)	13	(41.9%)	2	(4.8%)
Ethnicity										
Khmu	89	(61.4%)	20	(58.8%)	37	(97.4%)	11	(35.5%)	21	(50.0%)
Hmong	36	(24.8%)	0	(0.0%)	0	(0.0%)	17	(54.8%)	19	(45.2%)
Lao	20	(13.8%)	14	(41.2%)	1	(2.6%)	3	(9.7%)	2	(4.8%)
Primary source of living for household										
Cash crops or subsistence farming	130	(86.9%)	29	(85.3%)	37	(97.4%)	24	(77.4%)	40	(95.2%)
Government employee	7	(4.8%)	3	(8.8%)	1	(2.6%)	3	(9.7%)	0	(0.0%)
Shop or restaurant	3	(2.1%)	0	(0.0%)	0	(0.0%)	2	(6.5%)	1	(2.4%)
Private sector employee	3	(2.1%)	2	(5.9%)	0	(0.0%)	1	(3.2%)	0	(0.0%)
No source of income	2	(1.4%)	0	(0.0%)	0	(0.0%)	1	(3.2%)	1	(2.4%)
Number of children in household	4.11	(1.19)	4.27	(1.04)	3.68	(.84)	4.39	(1.28)	4.29	(1.29)
On the "Poor Household" list of the district	102	(70.3%)	11	(33.3%)	21	(55.3%)	29	(93.5%)	42	(100.0%)
WASH Knowledge										
(a) Causes of diarrhea	3.64	(0.94)	3.48	(0.80)	3.50	(0.65)	4.13	(0.72)	3.55	(1.27)
(b) Prevention of diarrhea	4.83	(1.47)	4.39	(1.06)	4.29	(0.98)	6.03	(1.25)	4.81	(1.82)
Total WASH Knowledge score	8.48	(2.15)	7.88	(1.65)	7.79	(1.28)	10.16	(1.68)	8.36	(2.76)
WASH Practices										
(a) Proper disposal of child feces	1.44	(1.08)	1.92	(1.16)	1.32	(1.17)	1.42	(0.95)	1.43	(0.95)
(b) Handwashing after child defecation	1.18	(1.00)	1.89	(1.25)	1.10	(0.94)	0.78	(0.67)	1.09	(0.82)
(c) Caregiver handwashing prior to feeding/preparing food	1.20	(0.97)	1.59	(1.31)	1.15	(0.85)	0.92	(0.96)	1.20	(0.67)
(d) Washing child's hands prior to feeding/eating	1.14	(0.88)	1.61	(1.24)	1.35	(0.80)	0.77	(0.52)	1.01	(0.66)
(e) Giving child adequately treated water	1.93	(0.61)	1.97	(0.95)	1.94	(0.25)	1.83	(0.38)	1.94	(0.59)
Mean WASH Practices Score	1.35	(0.74)	1.80	(1.11)	1.37	(0.52)	1.14	(0.39)	1.33	(0.53)

Note. Values for parent age, number of children in household, caregiver WASH knowledge, and caregiver WASH practices are presented as mean (standard deviation). Data are otherwise presented as *n* (valid percentage).

Table 4

Baseline (T_0) Characteristics of Children by Village

	Total Sample (n = 145)		Village A: WASH (*n* = 34)		Village B: Stimulation (*n* = 38)		Village C: WASH + Stimulation (*n* = 31)		Village D: Control (*n* = 42)	
Child Sample Characteristics	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)	*n* or *M*	(% or *SD*)
Child age (months)	20.44	(12.49)	26.62	(12.59)	15.56	(10.19)	23.33	(12.50)	17.80	(12.10)
Female gender	72	(49.7%)	19	(55.9%)	18	(47.4%)	14	(45.2%)	21	(50.0%)
Anthropometrics										
Height for age z-score (HAZ)	-1.11	(1.61)	-1.48	(1.32)	-0.93	(1.67)	-0.96	(1.62)	-1.10	(1.76)
Stunted (HAZ < -2.0)	49	(33.8%)	12	(35.3%)	12	(31.6%)	8	(25.8%)	17	(40.5%)
Weight for height z-score (WHZ)	0.05	(1.51)	0.01	(1.33)	0.42	(1.60)	-0.40	(1.23)	0.09	(1.69)
Wasted (WHZ < -2.0)	13	(9.0%)	3	(8.8%)	1	(2.6%)	3	(9.7%)	6	(14.3%)
Weight for age z-score (WAZ)	-0.61	(1.29)	-0.83	(0.99)	-0.22	(1.57)	-0.93	(1.11)	-0.56	(1.30)
Clinically Underweight (WAZ < -2.0)	18	(12.4%)	4	(11.8%)	6	(15.8%)	3	(9.7%)	5	(11.9%)
Cognitive & Language Development										
Cognitive development z-score	-1.39	(1.37)	-0.94	(1.80)	-1.54	(1.05)	-1.77	(0.89)	-1.32	(0.21)
Language development z-score	-0.73	(1.39)	-.41	(1.66)	-1.13	(1.18)	-1.28	(0.99)	-1.11	(0.21)
Diarrheal Episodes										
Child has had at least 1 diarrheal episode	86	(59.3%)	15	(44.1%)	23	(60.5%)	20	(64.5%)	28	(66.7%)
Length of time since most recent episode										
< 1 month ago	51	(35.2%)	10	(29.4%)	12	(31.6%)	7	(22.6%)	22	(52.4%)
> 1 month ago	35	(24.1%)	5	(14.7%)	11	(28.9%)	13	(41.9%)	6	(14.3%)
Length of longest diarrheal episode ever										
1-2 days	16	(11.0%)	6	(17.6%)	6	(15.8%)	1	(3.2%)	3	(7.1%)
3-5 days	55	(37.9%)	7	(20.6%	14	(36.8%)	13	(41.9%)	21	(50.0%)
> 6 days	15	(10.3%)	2	(5.9%)	3	(7.9%)	6	(19.4%)	4	(9.5%)
Frequency of diarrheal episodes										
Only 1 episode ever	21	(14.5%)	2	(5.9%)	3	(7.9%)	9	(29.0%)	7	(16.7%)
1-2 episodes/year	43	(29.6%)	8	(23.5%)	14	(36.8%)	4	(12.9%)	17	(40.5%)
3-4 episodes/year	16	(11.0%)	2	(5.9%)	6	(15.8%)	4	(12.9%)	4	(9.5%)
> 5 episodes/year	6	(4.1%)	3	(8.8%)	0	(0.0%)	3	(9.7%)	0	(0.0%)
Location child usually treated for diarrhea										
Home	27	(18.6%)	7	(20.6%)	17	(44.7%)	1	(3.2%)	2	(4.8%)
Hospital	54	(37.2%)	5	(14.7%)	3	(7.9%)	19	(61.3%)	27	(64.3%)
Health center	6	(4.1%)	3	(8.8%)	3	(7.9%)	0	(0.0%)	0	(0.0%)

Note. Values for child age, child anthropometrics, and cognitive and language development presented as mean (standard deviation). Data are otherwise presented as *n* (valid percentage).

Table 5

Bivariate Associations for All Study Variables

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1. Received WASH intervention	-																										
2. Received responsive stimulation intervention	.002	-																									
3. Child age	.33**	-.11	-																								
4. Child Gender (female > male)	.02	-.06	.04	-																							
5. Caregiver gender (female > male)	.03	-.04	.04	-.02	-																						
6. Caregiver education (primary education > none)	-.05	-.44**	.04	.01	.07	-																					
7. Caregiver education (secondary education > none)	-.02	.31**	-.15	-.01	-.08	-.53**	-																				
8. Caregiver education (secondary education > none)	.12	.36**	.02	.03	-.01	-.31**	-.34**	-																			
9. Ethnicity (Khmu > Lao)	-.25**	.16	-.14	-.01	-.07	-.01	.16	-.07	-																		
10. Ethnicity (Hmong > Lao)	.03	-.004	-.01	.004	.01	-.03	-.27**	.13	-.73**	-																	
11. Number of children in household	.14	-.09	.001	.02	.07	.17*	-.23**	-.01	-.27**	.23**	-																
12. Caregiver WASH Knowledge (T0)	.20*	.17*	.12	-.16	.07	-.01	-.10	.15	-.16	.23**	-.01	-															
13. Caregiver WASH Knowledge (T2)	.38**	.13	.11	-.02	.17	-.03	-.10	.17*	-.24**	.18*	.11	.21*	-														
14. Caregiver WASH Practices (T0)	.15	-.13	.22**	.06	-.02	-.05	.04	.11	-.02	-.17*	.06	-.29**	.06	-													
15. Caregiver WASH Practices (T2)	.42**	-.03	.12	-.02	-.05	-.10	.09	.01	-.18*	-.06	.06	-.10	-.17*	.15	-												
16. Child had diarrheal episode in last month (T0)	-.17*	-.15	-.12	-.01	-.05	.25**	.23**	-.10	.08	.08	.03	-.02	-.02	-.17*	-.14	-											
17. Child had diarrheal episode in last month (T2)	-.18*	-.13	-.16*	.004	-.06	-.01	.01	-.15	.08	-.03	-.03	-.14	-.35**	.08	.19*	.19*	-										
18. Child cognitive development z-score (T0)	.14	-.27**	.46**	.11	.19*	.04	-.05	-.10	-.06	-.17*	.01	-.28**	.06	.38**	.07	-.06	-09	-									
19. Child cognitive development z-score (T2)	.16	-.09	.63**	.03	.11	-.03	-.05	.05	-.01	-.16	-.08	-.08	.03	.30**	.12	-.13	-.19*	.78**	-								
20. Child language development z-score (T0)	.15	-.18*	.44**	.05	.20*	.03	-.004	-.11	-.06	-.17*	.06	-.25**	.13	.39**	.06	-.07	-.12	.92**	.75**	-							
21. Child language development z-score (T2)	.22**	-.08	.58**	.06	.10	-.03	.02	.01	-.02	-.20*	-.05	-.11	.06	.33**	.17*	-.14	-.17*	.78**	.93**	.80**	-						
22. Child height-for-age z-score (HAZ) (T0)	-.07	.10	-.13	.15	.14	.04	-.07	.04	.20*	-.17*	-.04	.002	.10	-.01	-.09	.02	.04	.12	.03	.12	.06	-					
23. Child height-for-age z-score (HAZ) (T2)	-.08	.08	-.14	.13	.13	.07	-.09	.03	.22**	-.20*	-.03	.004	.10	-.01	-.08	.03	.03	.09	.001	.10	.03	.98**	-				
24. Child weight-for-age z-score (T0)	-.19*	.06	-.26**	.03	-.03	-.06	.10	-.01	.19*	-.16	-.12	-.07	-.07	.11	-.15	-.01	.07	.010	.01	.09	.002	.49**	.48**	-			
25. Child weight-for-age z-score (T2)	-.17*	.07	-.27**	.01	-.03	-.07	.09	.01	.21*	-.18*	-.12	-.06	-.05	.09	-.15	-.01	.07	.08	-.01	.08	.001	.51**	.49**	.98**	-		
26. Child weight-for-age z-score (T0)	-.14	-.002	-.21*	-.04	-.19*	-.15	.18*	.01	.01	.02	-.09	-.05	-.09	.13	-.09	-.03	.03	.02	.01	.02	-.04	-.16*	-.19*	.71**	.66**	-	
27. Child weight-for-height z-score (T2)	-.04	-.06	-.22**	.05	-.09	-.09	.22**	-.08	.17*	-.25**	-.09	-.11	-.05	.18*	-.06	-.02	.06	.15	.05	.15	.06	.32**	.32**	.90**	.88**	.75**	-

Note: T0 = Baseline, T2 = one-month post intervention

*$p < .05$, **$p < .01$

Greater caregiver WASH knowledge at baseline was associated with greater WASH knowledge at T_2. Greater caregiver WASH knowledge at baseline was also associated with lower child cognitive and language development scores at baseline. Unexpectedly, greater caregiver WASH knowledge at T_2 was associated with less frequent self-reported caregiver WASH practices at T_2. However, greater caregiver WASH knowledge at T_2 was associated with less occurrences of diarrheal episodes within the month since receiving the intervention. More frequent self-reported caregiver WASH practices at baseline was associated with less occurrences of child diarrheal episodes within the month after intervention delivery. More frequent caregiver WASH practices at baseline was also associated with greater child cognitive and language development scores at baseline and one-month post-intervention, as well as greater HAZ scores at T_2. At one-month post-intervention, children who had experienced a diarrheal episode within the past month were associated with lower child cognitive and language development scores at T_2. Children's cognitive and language development scores were highly correlated at T_0 and T_2, as were children's HAZ, WAZ, and WHZ scores.

WASH intervention acceptability and feasibility (Aim 1)

Of the caregivers who received the WASH intervention alone or in combination with the responsive stimulation intervention, 100% (n = 63) reported that the health workers were clear and easy to understand during the presentation of the program. Additionally, 100% of caregivers reported that the WASH program was useful, and that the WASH counseling card was useful. Further, 100% reported that the WASH program was helpful for their child and was beneficial for the caregivers. While only 72.3% (n = 47) of caregivers reported that the WASH recommendations were easy to put into practice, 100% of caregivers reported that they would recommend the WASH program to other families. A post-hoc test revealed that caregivers who reported that the WASH practices would be difficult to put into practice were less likely to have regular access to soap, $\chi^2(1) = 9.49$, p = .002. In short, caregivers found the WASH intervention to be acceptable in terms of the intervention being useful and beneficial to themselves and their children. In terms of feasibility, most perceived that the WASH recommendations would be easy to put into practice.

WASH Intervention Effects on Caregiver WASH Knowledge & Practices (Aim 2)

Manipulation and Maintenance Checks of WASH Intervention

A manipulation check of the WASH intervention was conducted using a paired-samples t-test to compare caregiver WASH knowledge total scores between baseline (T_0) and immediately following the intervention (T_1) among caregivers from Villages A and C who received the WASH intervention (n = 65). Caregiver total WASH knowledge increased from T_0 (M = 8.98, SD = 2.01) to T_1 (M = 11.92, SD = 2.03, $t(63)$=-7.49, p < .001), suggesting that the WASH intervention successfully enhanced caregiver's WASH knowledge. A maintenance check of the WASH intervention was also conducted using a paired-samples t-test to compare caregiver WASH knowledge scores between baseline (T_0) and one month post-intervention (T_2) among caregivers who received the WASH intervention. Caregiver total WASH knowledge scores were significantly higher at T_2 (M = 11.41, SD = 1.88,) relative to T_0 (M = 8.98, SD = 2.01, $t(63)$=-8.32, p < .001), suggesting that WASH knowledge from the intervention was maintained one month later.[2] Furthermore, the effect was maintained with no difference between T_1 and T_2. See Figure 9 for a graphical representation of mean caregiver WASH knowledge total scores by time point.

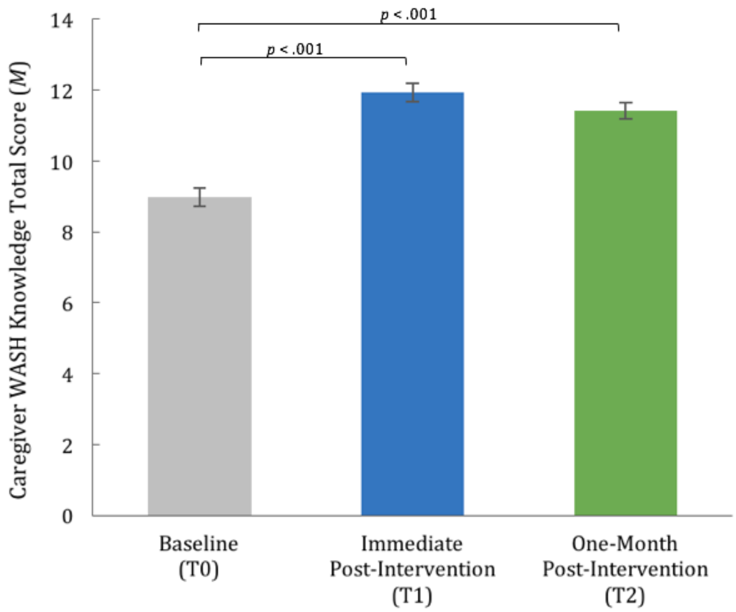


Figure 9. Manipulation and Maintenance Checks of WASH Intervention on Caregiver WASH Knowledge. The figure displays unadjusted mean WASH knowledge scores among caregivers from Villages A and C who received the WASH intervention (n = 65). Error bars represent standard error.

Intervention effects on Caregiver WASH Knowledge

A 2x2 factorial ANCOVA revealed that there were differences in WASH knowledge scores across intervention groups at one month post-intervention (T_2), after adjusting for baseline (T_0) WASH knowledge, F (4, 140) = 12.93, $p < .001$,

[2] We also performed individual manipulation and maintenance checks on each the two sub-scales of WASH knowledge ("causes of diarrhea" knowledge and "prevention of diarrhea" knowledge). These results mirrored those of the total WASH score.

partial η^2 = .27.[3] Specifically, there was a significant two-way interaction between the WASH intervention and the responsive stimulation intervention, F (1, 136) = 18.259, p <.001, partial η^2 = .115. This interaction is displayed graphically in Figure 10. Descriptives of caregiver WASH knowledge at baseline and one-month post-intervention are presented in Table 6.

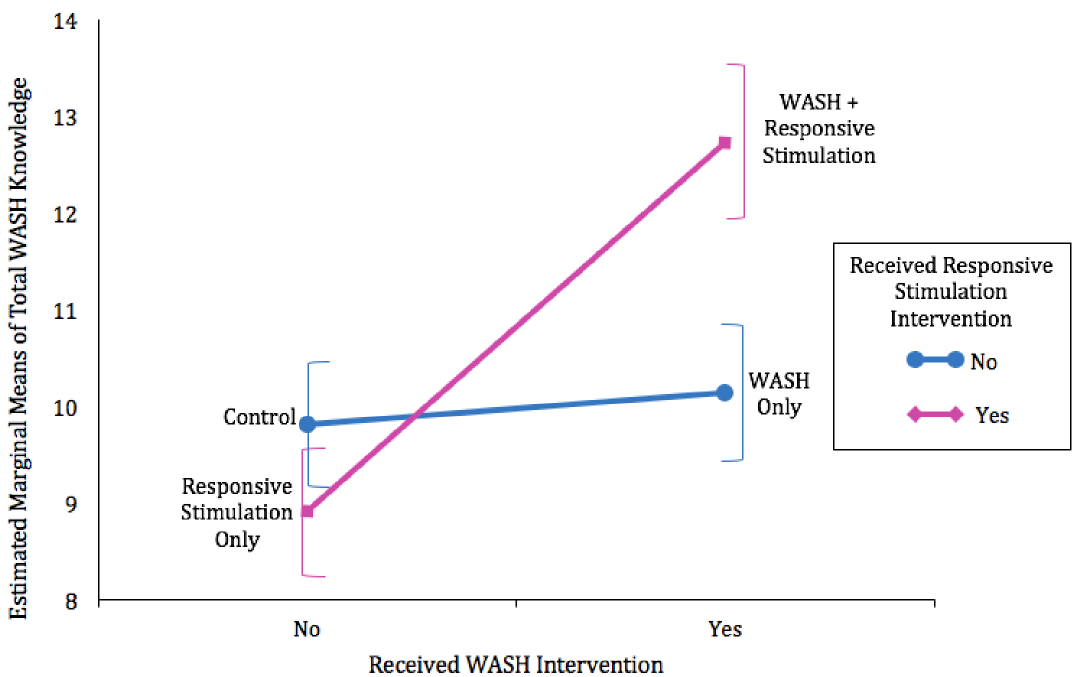


Figure 10. Estimated marginal means of total caregiver WASH knowledge at one month post-intervention (T_2), controlling for baseline (T_0) caregiver WASH knowledge. Note: Brackets display 95% confidence intervals.

[3] We performed a second 2x2 factorial ANCOVA to adjust for potential confounding sociodemographic variables (child age, caregiver age, ethnicity, and caregiver education). This analysis revealed a similar set of results, but did not better explain the variance in the dependent variable. Therefore, we only reported the results of the initial ANCOVA.

Table 6

Descriptives of Baseline (T_0) and One-Month Post Intervention (T_2) Variables by Intervention Group

Outcome variable	Village A: WASH Only	Village B: Responsive Stimulation Only	Village C: WASH + Responsive Stimulation	Village D: Control
Caregiver WASH Knowledge				
T_0 Baseline *M* (*SD*)	7.88 (1.65)	7.79 (1.28)	10.16 (1.68)	8.36 (2.76)
T_2 Post-Intervention $^{a}M_{adj}$ (*SE*)	10.15 (0.35)	8.93 (0.38)	12.73 (0.44)	9.81 (0.35)
Caregiver WASH Practices				
T_0 Baseline *M* (*SD*)	1.80 (1.11)	1.37 (0.52)	1.14 (0.39)	1.33 (0.53)
T_2 Post-Intervention $^{a}M_{adj}$ (*SE*)	1.86 (0.08)	1.34 (0.09)	1.73 (1.00)	1.29 (0.08)
Child Diarrheal Episode in Past Month				
T0 Baseline % Yes (No)	29.4 (70.6)	31.6 (68.4)	22.6 (77.4)	52.4 (47.6)
T2 Post-Intervention % Yes (No)	32.3 (77.4)	34.2 (65.8)	5.9 (85.3)	35.7 (64.3)
Child HAZ				
T_0 Baseline *M* (*SD*)	-1.48 (1.32)	-0.93 (1.67)	-0.96 (1.62)	-1.10 (1.76)
T_2 Post-Intervention $^{a}M_{adj}$ (*SE*)	-1.21 (0.05)	-1.12 (0.05)	-1.13 (0.05)	-1.04 (0.05)
Child WAZ				
T_0 Baseline *M* (*SD*)	-0.83 (0.99)	-0.22 (1.57)	-0.93 (1.11)	-0.56 (1.30)
T_2 Post-Intervention $^{a}M_{adj}$ (*SE*)	-0.62 (0.04)	-0.61 (.04)	-0.54 (0.05)	-0.62 (0.04)
Child WHZ				
T_0 Baseline *M* (*SD*)	0.01 (1.33)	0.42 (1.60)	-.40 (1.23)	0.09 (1.69)
T_2 Post-Intervention $^{a}M_{adj}$ (*SE*)	0.05 (0.15)	0.11 (.15)	-.63 (0.16)	-0.58 (0.14)
Child Cognitive Development				
T_0 Baseline *M* (*SD*)	-0.94 (1.80)	-1.54 (1.05)	-1.77 (0.89)	-1.32 (0.21)
T_2 Post-Intervention $^{b}M_{adj}$ (*SE*)	-1.33 (0.16)	-0.83 (0.14)	-0.96 (0.16)	-1.22 (0.13)
Child Language Development				
T_0 Baseline *M* (*SD*)	-0.41 (1.66)	-1.13 (1.18)	-1.28 (0.99)	-1.11 (0.21)
T_2 Post-Intervention $^{b}M_{adj}$ (*SE*)	-0.80 (0.14)	-.75 (0.13)	-0.70 (0.14)	-.1.00 (0.12)

Note: All baseline (T_0) measures are presented as means and standard deviations, except the measure for child diarrheal episodes, which is presented as observed frequencies (%). All one month post-intervention measures (T_2) are presented as adjusted means and standard errors, except the measure for child diarrheal episodes, which is presented as observed frequencies (%).

[a] Adjusted means account for the baseline measure of the outcome variable.

[b] Adjusted means account for the baseline measure of the outcome variable, child age, caregiver age, ethnicity, and caregiver education

To further examine the significant interaction, an analysis of the main effects and simple main effects for each intervention was performed. There was a statistically significant main effect for WASH, in that the adjusted marginal mean for caregiver WASH knowledge was 2.07 points higher among caregivers who received the WASH intervention (n = 65; M_{adj} = 11.44, SE = .29) compared to those who did not receive the WASH intervention (n = 80; M_{adj} = 9.37, SE = .26), F (1, 140) = 28.08, p < .001, partial η^2 = .17. There was also a statistically significant main effect for the responsive stimulation intervention, in that the adjusted marginal mean for caregiver WASH knowledge was 0.85 points higher among caregivers who received the responsive stimulation intervention (n = 72; M_{adj} = 1.83, SE = .28) compared to those who did not receive the responsive stimulation intervention (n = 73; M_{adj} = 9.98, SE = .27), F (1, 140) = 4.73, p =0.03, partial η^2 = .03. An examination of simple main effects revealed that among those who received the WASH intervention, WASH knowledge was 3.81 points higher among caregivers who also received the responsive stimulation intervention (Village C, M_{adj} = 12.73, SE = .44) compared to receiving the responsive stimulation intervention alone (Village C, M_{adj} = 8.93, SE = .38), F(1, 150) = 40.57, p < .001, partial η^2 = .23.

As shown in Figure 11, the individual WASH knowledge response items that were recalled the most at one month post-intervention were that child diarrhea may be caused by direct contact with feces, unwashed hands, and untreated water, and that child diarrhea may be prevented through handwashing, proper disposal of feces, clean water, and appropriate food hygiene. Items that were less frequently recalled at one month post-intervention included keeping the yard clean or providing a clean play area for children.

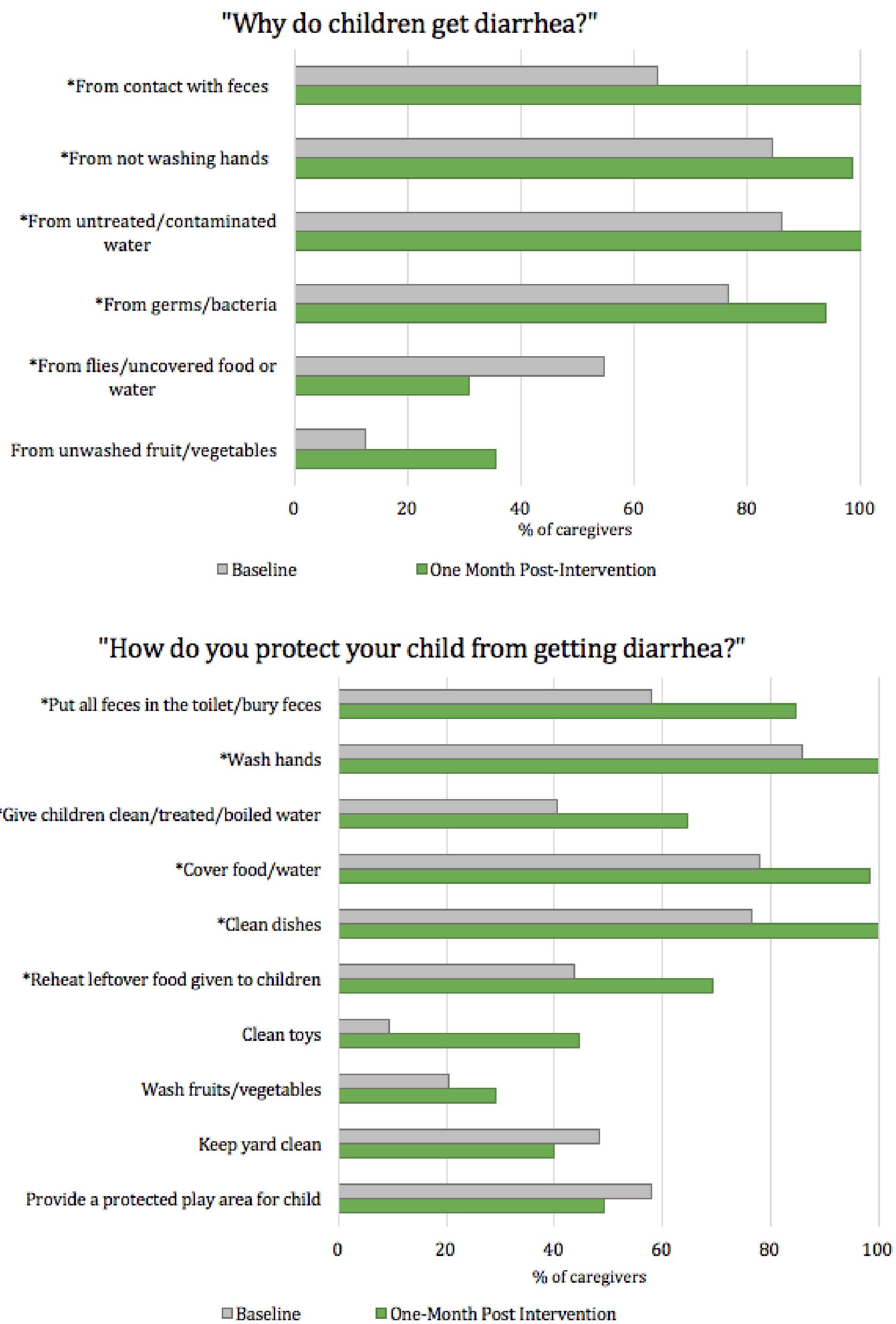


Figure 11. Caregiver WASH Knowledge item response frequencies at baseline and one month post-intervention. Caregivers were asked to provide as many correct responses as possible to the two WASH knowledge questions. Note: This figure only includes WASH knowledge responses from caregivers who received the WASH intervention (Villages A and C; n = 65). *Indicates knowledge items that were the most strongly emphasized in the WASH intervention.

In sum, there was an effect of the WASH intervention on WASH knowledge (large effect size, partial $\eta^2 = .17$). WASH knowledge measured at T_2 was over two points higher ($p < .001$) among those who received the WASH intervention, after controlling for baseline WASH knowledge. There was also a small effect (partial $\eta^2 = .03$) of the responsive stimulation intervention on WASH knowledge at T_2, but this result was driven by the group who received WASH in addition to responsive stimulation. Overall, WASH knowledge was highest among caregivers who received the combination of WASH + responsive stimulation interventions, suggesting that receiving both interventions may produce an additive or synergistic effect on WASH knowledge.

Intervention effects on Caregiver WASH Practices

A 2x2 factorial ANCOVA revealed that there were differences in self-reported caregiver WASH practices across intervention groups at one month post-intervention (T_2), after adjusting for baseline (T_0) WASH practices, F (4, 140) = 8.33, $p < .001$, partial $\eta^2 = .19$.[4] There was not a statistically significant interaction between the WASH intervention and responsive stimulation intervention on caregiver WASH practices at T_2, $p = .32$. There was, however, a significant main effect for the WASH intervention, in that the adjusted marginal mean for caregiver WASH practices was .48 points higher ($SE = .09$) among those who received the WASH intervention ($n = 65$; $M_{adj} = 1.80$, $SE = .07$), compared to those who did not

[4] We performed a second 2x2 factorial ANCOVA to adjust for potential confounding sociodemographic variables (child age, caregiver age, ethnicity, and caregiver education). This analysis revealed a similar set of results, but did not better explain the variance in the dependent variable. Therefore, we only reported the results of the initial ANCOVA.

receive the WASH intervention (n = 80; M_{adj} = 1.32, SE = .06), $F(1, 140) = 28.16$, $p <$ .001, partial η^2 = .17. WASH practice scores did not statistically differ among the two groups (Villages A and C) who received the WASH intervention, p = .35. The results from this analysis are displayed graphically in Figure 12. Descriptives of caregiver WASH practices at baseline and one-month post-intervention are presented in Table 6.

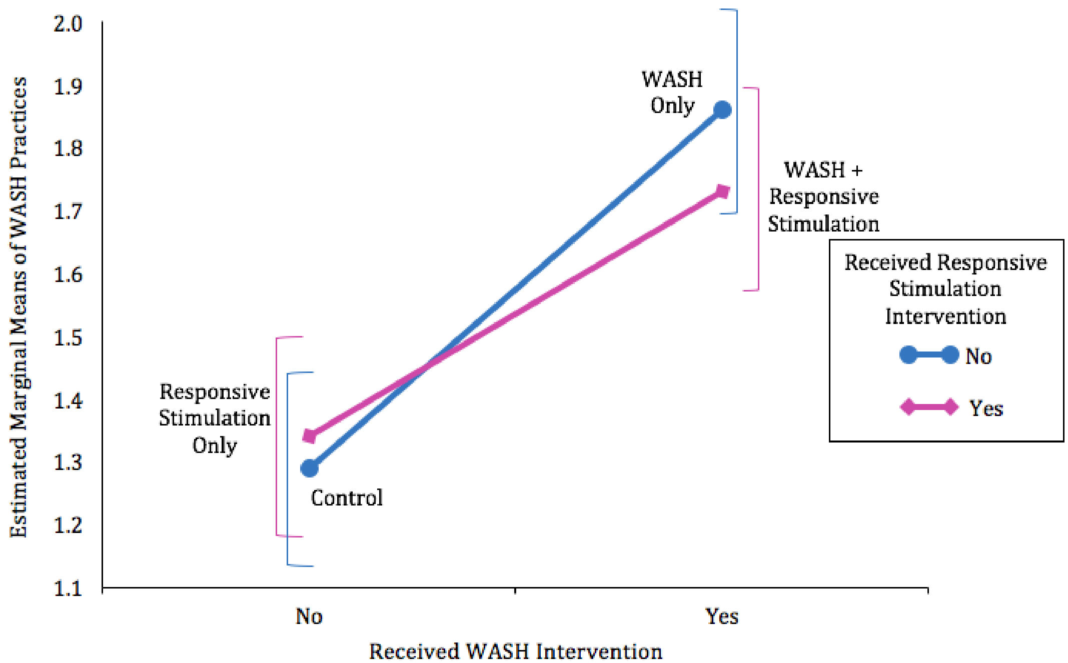


Figure 12. Estimated marginal means of self-reported caregiver WASH practices at one month post-intervention (T_2), controlling for baseline (T_0) caregiver WASH practices. Note: Brackets display 95% confidence intervals.

A more specific look into the individual WASH practice components (see Figure 13) shows that among those who received the WASH intervention, the practices that were reported to be used the least frequently were: washing the child's hands prior to feeding/eating, caregiver handwashing prior to feeding/preparing food, and handwashing after child defecation.

In sum, after controlling for baseline WASH practices, caregivers reported utilizing WASH practices more frequently at one month post-intervention (T_2) if they had received the WASH intervention (large effect size, partial $\eta^2 = .17$). Specifically, caregivers who received the WASH intervention scored nearly half a point higher ($p < .001$) on the WASH practices measure. In contrast to the WASH knowledge results, the addition of the responsive stimulation intervention did not significantly boost WASH practices over and above the WASH program alone.

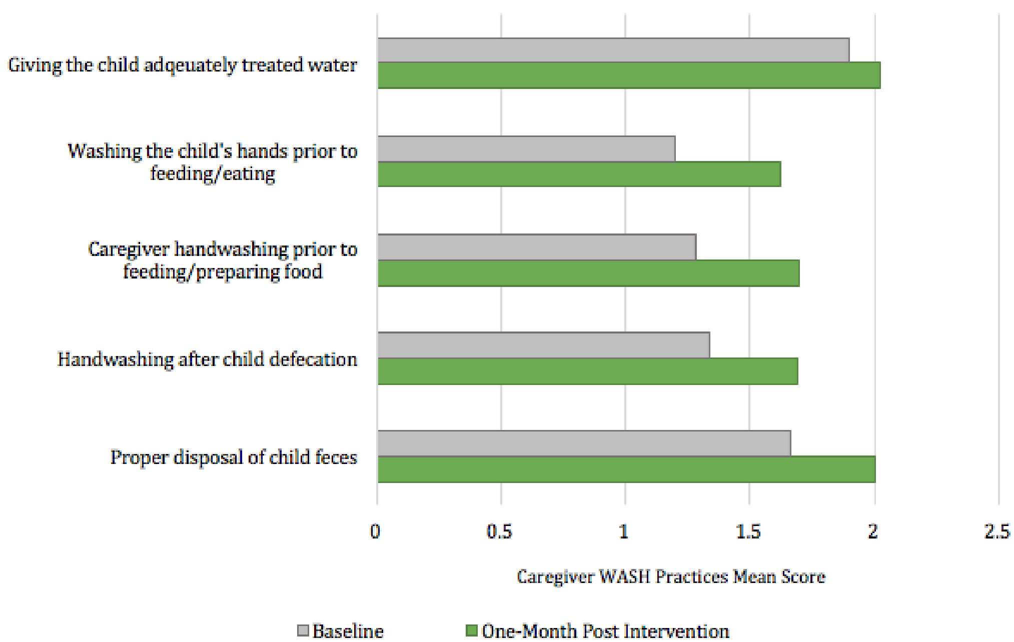


Figure 13. Caregiver WASH Practices items at baseline and one month post-intervention. Response options for each WASH practice item included: "never" (0), "rarely" (1), "sometimes" (2), "mostly" (3), and "always" (4). Note: This figure only includes WASH practice scores from caregivers who received the WASH intervention (Villages A and C; n = 65). In addition, the one-month post intervention means in this figure were adjusted for baseline differences.

WASH intervention Effects on Child Health & Developmental Outcomes (Aim 3)

Child Diarrheal Episodes

We performed a hierarchical binomial logistic regression to examine whether exposure to the WASH and/or responsive stimulation interventions predicted whether or not a child had experienced a diarrheal episode within the month after receiving the intervention(s). Table 7 presents the separate effects of multiple predictors across a series of three logistic models. Model 1 tested the effects of covariate factors on the outcome, including child age and whether or a not a child had diarrhea in the month prior to baseline (other sociodemographic covariates, such as caregiver age, education, and ethnicity, were also tested, but did not explain additional variance in the model and were therefore removed); model 2 added the main effects for each of the interventions (received WASH, received responsive stimulation); and model 3 added the intervention interaction term (WASH x responsive stimulation).

Model 1 was significant, $\chi^2(2) = 8.31$, $p = .016$ and explained 8.0% (Nagelkerke R^2) of the variance in diarrheal outcomes. According to this model, children who had experienced a diarrheal episode in the month prior to baseline were 2.24 times more likely to have another diarrheal episode the following month between baseline and T_2. Furthermore, although the finding was not significant ($p = .073$), there was a general trend with age, in that the older children were, the less likely they were to have experienced a diarrheal episode in the month between baseline and T_2. Though the main effects for WASH and the responsive stimulation

Table 7
Summary of Logistic Regression Model Examining the Effects of the WASH and Responsive Stimulation Interventions on Predicting Likelihood of Whether or Not a Child Diarrheal Episode Occurred in the Past Month

	Model 1				Model 2				Model 3			
			95% CI				95% CI				95% CI	
Predictor variables	OR	*p*	Lower	Upper	OR	*p*	Lower	Upper	OR	*p*	Lower	Upper
Covariates												
Child diarrheal episode occurred in month prior to baseline (Ref = No)	**2.244**	**0.037**	1.052	4.789	1.922	0.101	0.880	4.197	2.066	0.073	0.934	4.574
Child age	0.972	0.073	0.942	1.004	0.976	0.158	0.944	1.009	0.975	0.140	0.942	1.008
Main Effects												
Received WASH intervention (Ref = No)					0.549	0.158	0.239	1.262	1.098	0.861	0.385	3.132
Received responsive stimulation intervention (Ref = No)					0.571	0.163	0.260	1.254	1.034	0.945	0.396	2.703
Interaction Effect												
WASH x responsive stimulation									**0.146**	**0.047**	0.022	0.973
Model Statistics												
Chi-square	8.314				12.399				16.960			
df	2				4				5			
Model significance	0.016				0.015				0.005			
-2 Log likelihood	162.496				158.412				153.851			
Nagelkerke R Sqaure	0.080				0.118				0.159			

Note: OR = odds ratio, CI = confidence interval

interventions in Model 2 did not add any significant predictors to the model, the overall model was significant and an improvement over Model 1, $\chi^2(4)$ = 12.399, p =.015 (with 11.8% of the variance explained). The addition of the interaction term in Model 3 also significantly improved the overall model, $\chi^2(5)$ = 16.960, p =.005 (with 15.9% of the variance explained) and revealed a significant interaction effect for WASH x responsive stimulation (p = .047). This interaction effect suggests that the effect on child diarrhea depended upon the combination of the interventions received. Specifically, children were approximately 84% less likely to have experienced a diarrheal episode in the month following intervention delivery if their caregivers had received both the WASH and responsive stimulation interventions. This effect is further illustrated in Figure 14, which displays the observed frequencies of children who did and did not experience a diarrheal episode in the month following intervention delivery.

In sum, there may be a synergistic effect of receiving both the WASH and responsive stimulation interventions, in that the combination of receiving these interventions significantly reduces the likelihood of child diarrheal episodes.

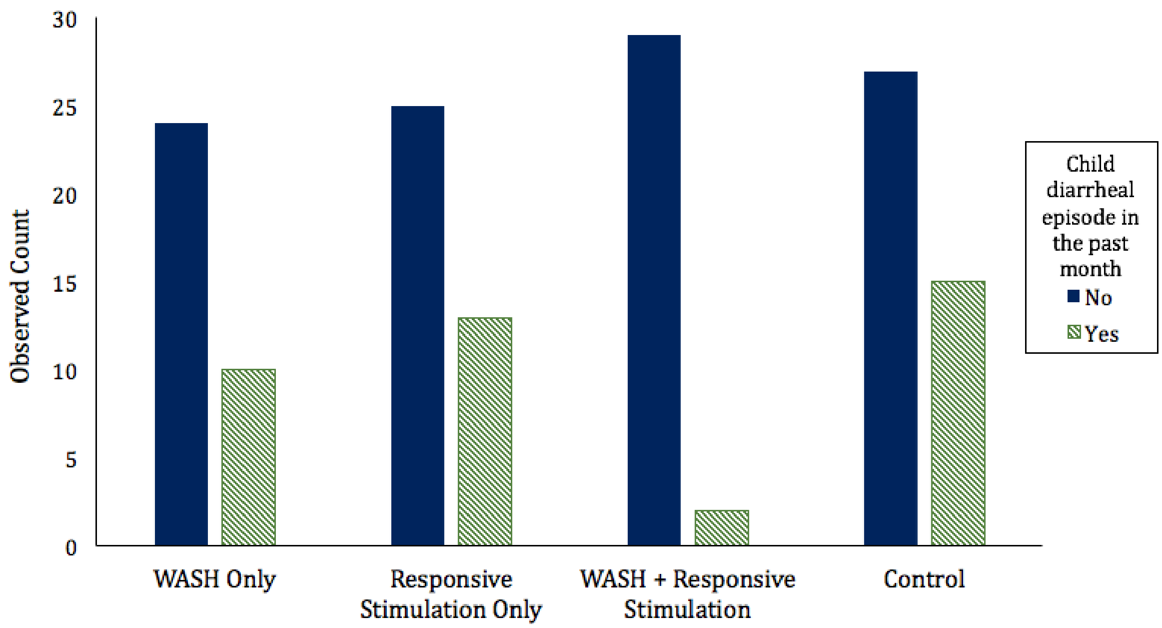


Figure 14. Observed frequencies of children by intervention group who did and did not experience a diarrheal episode in the month following intervention delivery.

Post-Hoc Test Examining WASH Practices as a Moderator of Child Diarrhea Likelihood

A post-hoc logistic regression analysis was performed to examine whether caregiver WASH practices moderated the likelihood that a child would experience a diarrheal episode post-intervention. We used a similar model as described above, but also included WASH practices scores, the interaction between WASH practices scores and each of the interventions, and the three-way interaction between WASH practices scores, the WASH intervention, and the responsive stimulation intervention. The inclusion of interaction terms significantly improved model fit ($\chi^2(9) = 25.527$, $p < .001$, 27.3% Nagelkerke R^2) over the model without interaction terms ($\chi^2(3) = 17.02$, $p < .001$, 16.0% Nagelkerke R^2). There was a significant three-way interaction, which indicated that the likelihood of child diarrheal episodes occurring in the month after intervention delivery *decreased* among caregivers who had *higher* WASH practices scores in the combined group (see Figure 15 for a graphical display of this effect). Therefore, our data suggests that WASH practices, as well as the type of intervention that was delivered, moderated the likelihood that a child would experience a diarrheal episode post-intervention.

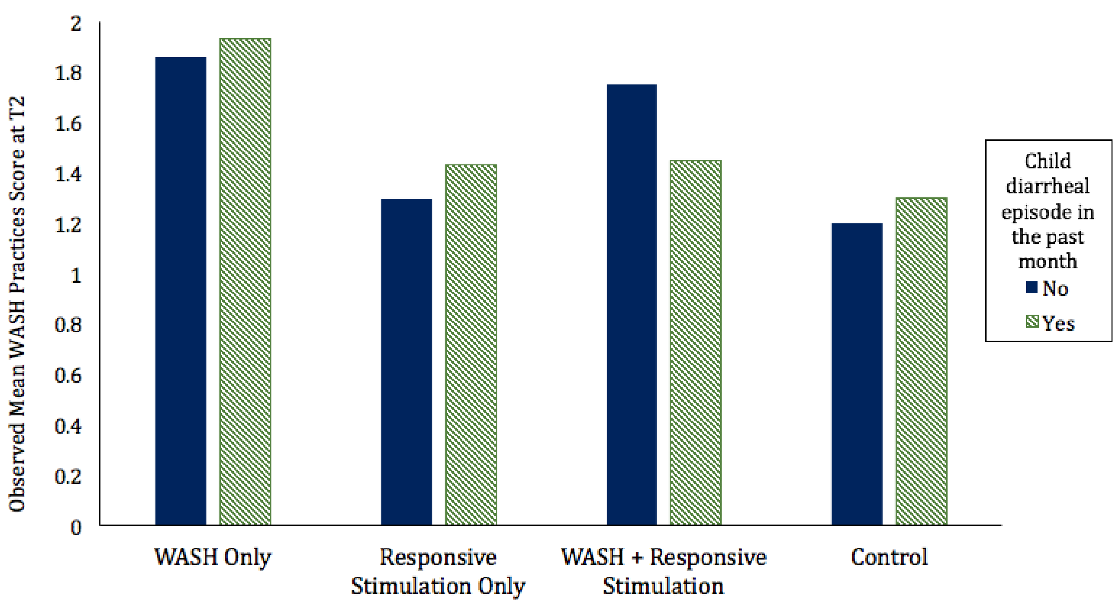


Figure 15. Observed mean WASH practices scores (at one month post-intervention) across villages among caregivers who did or did not have a child experience a diarrheal episode in the month following intervention delivery. As illustrated, caregivers in the combined group with higher WASH practice scores at one month post-intervention were less likely to have children who experienced diarrheal episodes in the month after intervention delivery.

Child Anthropometrics

A series of 2x2 factorial ANCOVAs revealed that there were no between-group differences in child HAZ, WAZ, or WHZ at one month post-intervention (T_2)

after adjusting for baseline anthropometric measurements. These results remained the same after performing a second ANCOVA analysis controlling for sociodemographic variables (child age, caregiver age, ethnicity, and caregiver education). Descriptives of child anthropometric measurements at baseline and one-month post-intervention are presented in Table 6.

In sum, there was no effect for the WASH or the responsive stimulation intervention on child anthropometric measurements one month post-intervention.

Child Cognitive Development

A 2x2 factorial ANCOVA revealed that there were differences in child cognitive development scores across intervention groups at one month post-intervention (T_2), after adjusting for baseline (T_0) cognitive development scores, F (4, 140) = 57.82, p < .001, partial η^2 = .62. We also performed a second 2x2 factorial ANCOVA to adjust for other potential confounding sociodemographic variables (child age, caregiver age, ethnicity, and caregiver education). This analysis revealed a similar set of results, but better explained the variance in post-intervention cognitive development scores (partial η^2 = .72). The results from the second ANCOVA are described below.

There was not a statistically significant interaction between the WASH intervention and responsive stimulation intervention on child cognitive development scores at T_2, after controlling for baseline cognitive development scores and sociodemographic variables, p = .96. There was, however, a significant main effect for the responsive stimulation intervention, in that the adjusted marginal mean for child cognitive development z-scores was .38 points higher (SE =

0.15) among those who received the responsive stimulation intervention (n = 72; M_{adj} = -.90, SE = .10), compared to those who did not receive the responsive stimulation intervention (n = 73; M_{adj} = -1.27, SE = .10), $F(1, 138) = 6.63$, $p < .001$, partial $\eta^2 = .05$. Child development scores did not statistically differ among the two groups (Villages B and C) who received the responsive stimulation intervention, p = .55. The results from this analysis are displayed graphically in Figure 16. Descriptives of child development z-scores at baseline and one-month post-intervention are presented in Table 6.

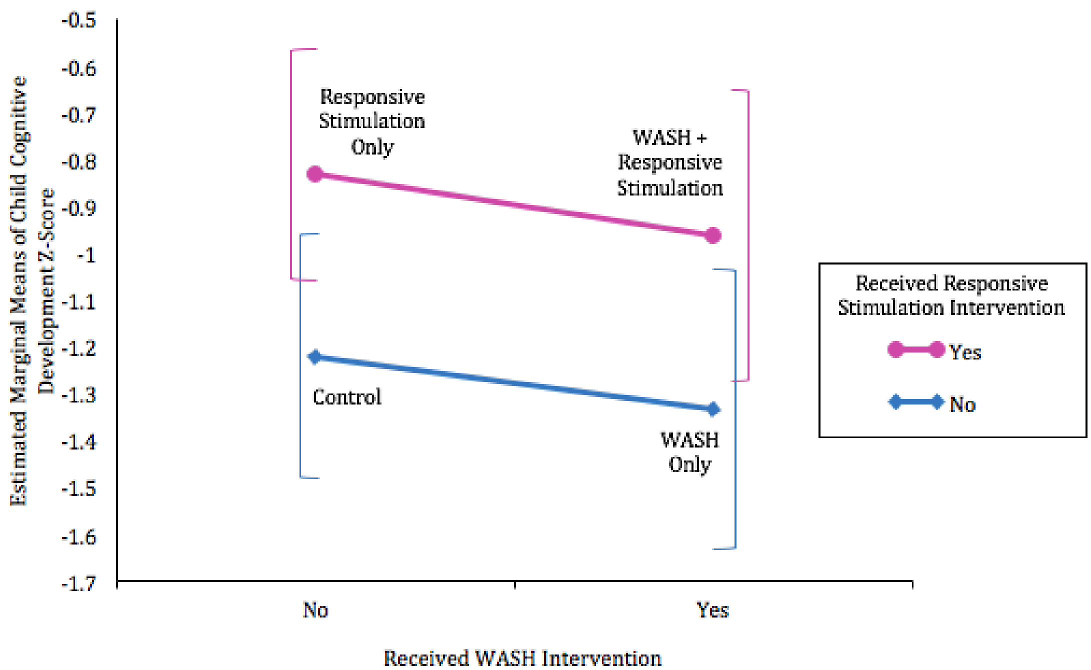


Figure 16. Estimated marginal means of self-reported caregiver WASH practices at one month post-intervention (T_2), controlling for baseline (T_0) caregiver WASH practices. Note: Brackets display 95% confidence intervals.

In sum, there was no effect for the WASH intervention on child cognitive development outcomes at one month post-intervention. However, the responsive stimulation intervention had an effect on child cognitive development outcomes (with a medium effect size, partial $\eta^2 = .05$), after controlling for baseline cognitive development scores, child age, caregiver age, ethnicity, and caregiver education. Specifically, children whose caregivers received the responsive stimulation intervention had cognitive development scores that were nearly half a standard deviation higher ($p < .001$) at one month post-intervention than children whose caregivers did not receive the responsive stimulation intervention.

Child Language Development

A 2x2 factorial ANCOVAs revealed that there were no between-group differences in child language development scores at one month post-intervention (T_2) after adjusting for baseline child development scores. These results remained the same after performing a second ANCOVA analysis controlling for sociodemographic variables (child age, caregiver age, ethnicity, and caregiver education). Descriptives of child anthropometric measurements at baseline and one-month post-intervention are presented in Table 6.

In a post-hoc test, we re-ran the analysis to include only children from the younger half of our sample (<26 months, n = 95). We found a small-to-moderate effect for the responsive stimulation intervention on children's language development, F (1, 88) = 3.95, $p = .049$, partial $\eta^2 = .04$. Specifically, children under 26 months of age whose caregivers received the responsive stimulation intervention had language development scores that were 0.32 standard deviations higher at one month after the intervention, compared to children whose caregivers did not receive the responsive stimulation intervention, $F(1, 86) = 4.35$, $p = .04$.

In sum, there was no effect for the WASH or the responsive stimulation intervention on child language development scores at one month post-intervention when the entire sample (n = 145) was included in the analysis. However, there was a small to moderate effect of the responsive stimulation intervention on child language development among the youngest children in our sample (<26 months, *n* = 95). Specifically, language development scores were about a third of a standard deviation higher at one month post-intervention among infants and toddlers (< 26 months) whose caregivers received the responsive stimulation intervention.

CHAPTER IV

DISCUSSION

This chapter contains unpublished co-authored material. M. Fong, C. Lattanavong, O. Inthachith, and J. Measelle contributed substantially to the study described in this chapter. I designed the study with M. Fong. Data collection was organized by C. Lattanavang and O. Inthachith. M. Fong took the lead on designing and overseeing the responsive stimulation intervention described in this chapter. I took the lead on designing and overseeing the WASH intervention described in this chapter. I wrote this chapter with editorial assistance from J. Measelle.

Young children living in poverty in LMICs are more likely to experience undernutrition, infectious diseases, environmental contaminants, and unstimulating surroundings. Exposure to such risks during the first 1,000 days of life leads to significant inequalities in a child's developmental trajectory. Child-focused WASH interventions have the potential to help create improved environmental conditions that are necessary for children to thrive. The current study examined the effects of a low-cost, easily scalable child-focused WASH intervention (targeting children ages 0-3) that was delivered in a single session to caregivers in Laos, a lower-middle income country in Southeast Asia. Specifically, we examined the effects of the child-focused WASH intervention on caregiver and child outcomes when the intervention was delivered independently, and in combination with a similarly efficient intervention focused on responsive caregiver stimulation.

Although the primary focus of this paper was to document the effects of the child-focused WASH intervention, we also examined synergistic effects related to the combination of the child-focused WASH and responsive stimulation interventions.

Our results support the overall effectiveness of the WASH intervention on a number of important dimensions. First, caregivers found the WASH intervention to be beneficial to themselves and their children, and most believed that child-focused WASH behaviors would be easy to put into practice (Aim 1). The WASH intervention also had significant benefits with large effect sizes on caregiver WASH knowledge and self-reported WASH practices at one month post-intervention (Aim 2). The WASH intervention did not, however, appear to influence child physical growth outcomes or cognitive/language development by one month post-intervention. Nevertheless, children were less likely to experience a diarrheal episode post-intervention if their caregivers received the WASH intervention in addition to a responsive stimulation intervention (Aim 3). These findings are discussed in more detail below.

WASH Intervention Acceptability and Feasibility (Aim 1)

In support of our first hypothesis, all caregivers who received the WASH intervention found the intervention to be acceptable and most found the recommended child-focused WASH practices to be feasible. However, over a quarter of caregivers believed the child-focused WASH practices would be difficult to put into practice. According to social cognitive theory (Bandura, 1977) and modified learning theory (Wallston, 1992), even if an individual believes the behavior will produce a positive outcome, they will only be motivated to perform the behavior to

the extent that they are confident in their ability to perform it successfully. Given the low frequency at which caregivers reported engaging in WASH practices at baseline, parents may have been aware
of the challenges associated with making lasting changes to household behavioral routines.

A post-hoc test revealed that caregivers who reported that the WASH practices would be difficult to put into practice were less likely to have regular access to soap. This finding could imply that the unavailability or unaffordability of soap was perceived as a barrier to WASH behavior change, which is consistent with findings from other studies (e.g., Phillips et al., 2015; Hoque, 2003). Although a bar of soap was provided to each family who participated in the WASH intervention, this did not address the long-term problem of soap unavailability in each of the respective villages. For many of the families in our study who likely live on less than $1.90 USD per day (UNDP, 2016), the cost of soap (at 20-50 cents per bar) is likely to be prohibitive. Based on the evidence that handwashing with soap is (a) more common when soap and water are provided at a convenient location (Luby et al., 2010), and (b) the most effective way to prevent disease (Cairncross & Valdmanis, 2006), it will be in the best interest of policymakers moving forward to prioritize the scaling up of handwashing interventions that guarantee the regular provision of soap. Future studies should examine whether increased availability of soap increases caregivers' confidence in their ability to change their household behavioral routines.

Overall, despite that some caregivers perceived that the implementation of WASH practices would be difficult, the data strongly supports the acceptability and perceived feasibility of the child-focused WASH intervention.

Intervention Effects on Caregiver WASH Knowledge and Practices (Aim 2)

WASH Knowledge

As hypothesized, caregivers who received the WASH intervention had greater WASH knowledge at one month post-intervention, relative to caregivers who did not receive the WASH intervention, after controlling for baseline scores. WASH knowledge, as defined in our study, included knowledge about the causes of feco-oral transmission in children, as well as the practices necessary to prevent such transmission. The individual WASH knowledge response items that were recalled the most at one month post-intervention were those that were, in fact, strongly emphasized in the WASH intervention (i.e., that child diarrhea may be caused by direct contact with feces, unwashed hands, and untreated water, and that child diarrhea may be prevented through handwashing, proper disposal of feces, clean water, and appropriate food hygiene). Items that were less frequently recalled at one month post-intervention, such as keeping the yard clean or providing a clean play area for children, were those that were not as strongly emphasized in the WASH intervention. Future child-focused WASH interventions should aim to include a greater emphasis on promoting clean yards and protected play areas. Given that young infants and toddlers who crawl on the ground and frequently put objects in their mouths are likely to directly ingest soil that has been directly contaminated by animal waste (Ngure et al., 2013), interventions that promote clean yards (i.e., corralling of animals to keep them separated from children) or protected play areas (i.e., playmats for immobile infants or a combination of a playmat/playpen for crawling and mobile infants) may help prevent direct ingestion of fecal pathogens from occurring (Ngure et al., 2014; USAID, 2018).

Interestingly, after controlling for baseline scores, WASH knowledge was highest among caregivers who received the WASH intervention with the addition of the responsive stimulation intervention, suggesting a possible additive or synergistic effect of both programs on WASH knowledge. However, it is likely that this result was at least partially driven by the fact that the combined intervention group started with significantly higher WASH knowledge at baseline relative to all the other groups (WASH knowledge was likely higher in this group because caregivers were more highly educated, relative to other groups). Nevertheless, it is particularly noteworthy that the combined intervention group experienced a significant increase in WASH knowledge, especially considering the criticism that combined programs often deliver too many messages to be retained (Stewart, 2016).

Previous studies have shown that combined interventions can be effective when there are few, doable messages (Yousafzai & Aboud, 2014). Perhaps the WASH and responsive stimulation interventions were each simple enough that, when delivered in combination, caregivers were not overloaded with too many messages and could therefore retain WASH knowledge messages. This might imply an additive effect. There also may have been a synergistic effect from the combination of the two interventions. For example, the focus on interacting with one's child with the goal of stimulating learning and development could have enhanced a caregiver's motivation for being committed to learning how to keep their child healthy.

It is also possible that WASH knowledge was enhanced and retained through the use of our single-page counseling cards, which provided a simplified visual summary of the key program messages. Posters and other visual aids have been shown to facilitate WASH knowledge in other studies (e.g., Akter & Ali, 2014; Phillips et al. 2015). Anecdotally, caregivers in our study found the counseling cards to be visually appealing and many reported that they hung them up in their homes. If true, increased exposure to the counseling cards may have enhanced WASH knowledge retention (Jenner et al., 2005). Future studies should consider measuring the use of counseling cards or other program materials outside of intervention sessions.

Overall, our findings suggest that a single-session of a low-cost WASH intervention can, at least in the short-term, enhance knowledge about hygiene practices that may protect children from feco-oral transmission. Given that WASH knowledge has previously been associated with increased compliance with hygiene practices (Phaswana-Majuya & Shukla, 2005), continued education through varied channels may help vulnerable households to practice appropriate hygiene behaviors to support early child development (Akter & Ali, 2014).

WASH Practices

As we expected, after controlling for baseline scores, caregivers who received the WASH intervention reported engaging in child-focused WASH practices more frequently at one month post-intervention compared to caregivers who did not receive the WASH intervention. This is consistent with other studies that also found increases in self-reported hygiene behaviors after the delivery of a brief WASH intervention (e.g., Snow, White, & Kim, 2008; Rabbi & Dey, 2013). In contrast to its enhancing effect on WASH knowledge, as just reported above, the addition of the responsive stimulation intervention did not significantly boost WASH practices relative to parents in the village who received WASH alone. This may largely be an artifact of the fact that caregivers in the WASH only group started with significantly and relatively higher WASH practice scores at baseline and that they, consequently, reported little change in the frequency of their WASH practices at one month post-intervention. The combined intervention group, on the other hand, reported greater change in WASH practices from baseline, compared to the WASH only group. While this could imply an additive or synergistic effect from the combined package of interventions on caregiver WASH practices, it is also possible that it could just be more challenging to increase the frequency of WASH practices among caregivers who are already engaging in the practices more often (Ouellette & Wood, 1998). The reverse may also be true, in that it may be easier to facilitate change among caregivers who more rarely engage in such practices (Greene et al., 2012).

Overall, the frequencies with which WASH practices were reported in our sample were objectively low. At one month post-intervention, the adjusted mean WASH practice score among all caregivers who received the WASH intervention was 1.80 (SE = .07), indicating that parents were reporting engaging in child-focused WASH practices somewhere between “rarely (1)” and “sometimes (2)”. This is consistent with other findings that child-focused hygiene practices among families in LMICs are infrequently used (Allegranzi & Pittet, 2007; Vindigni, Riley, & Jhung, 2011). Among those who received the WASH intervention, the practices that were reported to be used the least frequently included washing the child's hands prior to feeding/eating, caregiver handwashing prior to feeding/preparing food, and handwashing after child defecation. Other studies have also observed infrequent use of these particular WASH behaviors (e.g., Phillips et al., 2015), suggesting that these behaviors may be especially important targets for future studies.

Overall, our findings provide evidence that a single-session of a low-cost WASH intervention can, at least in the short-term, increase self-reported hygiene behaviors that aim to protect young children from feco-oral transmission. Future interventions, however, should aim to more substantially increase the frequency of WASH practices so that caregivers are engaging in such practices more regularly. For example, interventions that include regular motivational community meetings with large-scale participation, periodic home visits, and provision of free soap have been shown to facilitate improved hygiene behaviors (Akter & Ali, 2014; Phillips et al., 2015). Furthermore, the addition of mobile technologies, such as sending behavior change reminders through text messages, may be an additional cost-effective strategy that can improve hygiene behaviors across a large number of households (Schnall & Iribarren, 2015).

Intervention Effects on Child Health & Developmental Outcomes (Aim 3)

Child Diarrheal Episodes

Our capacity to impact child outcomes was the second major objective of this trial. Contrary to our prediction, the WASH intervention did not decrease children's likelihood of diarrheal episodes in the month following our WASH Program when it was delivered alone. However, when the responsive stimulation intervention was delivered in addition to the WASH intervention, the occurrence of child diarrheal episodes post-intervention decreased by 84%. This finding suggests that there may be an additive or synergistic effect from the combination of interventions.

It is possible that because both of the interventions were similarly designed to encourage nurturing caregiving practices, caregivers in the combined group may have been more motivated to engage in practices that aim to prevent feco-oral transmission among their children, thus decreasing the likelihood that a child would come into contact with fecal pathogens that might cause diarrheal illness. A post-hoc analysis of our data added support for this theory, as the likelihood of child diarrheal episodes occurring in the month after intervention delivery *decreased* among caregivers who had *higher* WASH practices scores in the combined group. This is consistent with other studies that have observed fewer child diarrheal episodes among households who utilize better WASH practices (e.g., Dangour et al., 2013; Luby et al., 2004). However, observational data on caregiver WASH behaviors would be helpful in future studies to further support this theory. In addition, future studies should investigate whether a reduced likelihood in child diarrheal episodes is sustained over time.

Child Anthropometrics

As expected, the WASH intervention did not have an effect on child anthropometric measurements one month post-intervention. Given the short duration of our study (1 month), significant changes in child HAZ, WAZ, and WHZ scores would have been unlikely (Prendergast & Humphrey, 2014). However, studies have shown that with proper nutrition and much more sensitive measurement (i.e., bone growth measurements), changes in growth can be detected on a weekly basis (Urlacher et al., 2016). Therefore, it is possible that with additional time and more sensitive measurement tools, we would have observed a change in child anthropometric measurements, especially among younger children under two years of age. For example, there is evidence that linear growth can increase during the first 1,000 days of life when a child's environment is significantly improved, such as through better WASH infrastructure/behaviors (Dearden et al., 2017; Langford, Lunn & Brick, 2011), nutrition/feeding practices (Schroeder et al., 2002; Prentice et al., 2013), psychosocial stimulation (Walker et al., 2011; Walker et al., 2007), or a combination of these elements (Grantham-McGregor et al., 1997; Grantham-McGregor et al. 2014).

It has recently been argued, however, that improving linear growth is not always a necessary outcome if an intervention still meaningfully affects other important nutritional or developmental outcomes (Leroy & Frongillo, 2019). For example, several interventions have been found to improve children's well-being in a meaningful way, though have had no effect on linear growth (e.g., Menon et al.. 2016). In addition, improving linear growth is not always sufficient to ensure that children develop to their full potential. For example, young children who grow sufficiently, but who lack adequate stimulation at home, are less likely to develop to their full potential (Leroy & Frongillo, 2019). Therefore, as we continue to develop programs that target early child development, it is important to recognize that nonsignificant effects on child growth outcomes may not be tantamount to program failure, especially in the short-run, if child outcomes are improved.

Child Cognitive and Language Development

Contrary to our prediction, we found no effect of the WASH intervention on parents' reports of children's cognitive or language development. This is inconsistent with other findings that have shown associations between improved hygiene practices and cognitive outcomes (Spears, 2011; Bowen, 2012). However, because the impact of WASH on cognitive development may operate through multiple pathways (i.e., through effects on malnutrition or infection), one month may not be enough time to observe changes either in children's nutrition-mediated immune systems or their cognitive development following delivery of the WASH intervention (Chandna et al., 2017). Future studies investigating the effects of child-focused WASH interventions should examine cognitive development across longer post-intervention periods.

Although we did not find an effect for the WASH intervention, we did find a moderate effect of the responsive stimulation intervention on caregivers' reports of children's cognitive development. Specifically, children whose caregivers received the responsive stimulation intervention had higher cognitive development scores one month after the intervention, compared to children whose caregivers did not receive the responsive stimulation intervention (i.e., from the WASH only and control groups). Examples of children's cognitive developmental constructs that developed from baseline included children's ability to pay attention, remember information, perceive and discriminate between objects and people in their environment, solve problems, and acquire basic knowledge.

Several studies have found similar effects for responsive stimulation interventions on children's cognitive development in LMICs (Aboud & Yousafzai, 2015; Britto et al., 2017l Rao et al,, 2014). A recent meta-analysis of 21 responsive stimulation interventions delivered to children in the first 1,000 days found a moderate effect (average Cohen's *d* = 0.42) of responsive stimulation interventions on children's cognitive development (Aboud & Yousafzai, 2015). Additionally, there is evidence that short-term effects of responsive stimulation interventions on child cognitive development can be observed within one month (Yousafzai et al., 2014). Furthermore, a recent study found that a brief responsive stimulation intervention (2 sessions) was effective at inducing positive short-term change in child development at six months post-intervention (Jin et al., 2017). Thus, there is sufficient evidence to support that brief interventions aimed at encouraging responsive caregiving and stimulation are effective for improving children's short-term cognitive outcomes.

We did not similarly observe a clinically significant effect of the responsive stimulation intervention on child language development. This finding was surprising, given that language is rapidly developing during this early period of development. However, when we re-ran the analysis to include children under 26 months only (n = 95), we found a small-to-moderate effect for the responsive stimulation intervention on children's language development. Specifically, children under 26 months of age whose caregivers received the responsive stimulation intervention had higher language development scores one month after the intervention, compared to children whose caregivers did not receive the responsive stimulation intervention. These results are consistent with findings that indicate that interventions within the first 1,000 days offers clear developmental advantages, due to the high degree of brain plasticity during this early period (Feldman, 2000; Wachs et al., 2014). Rapid neuronal proliferation and pruning, synaptogenesis, and white matter development during this early sensitive period makes the brain to be highly receptive to environmentally stimulating inputs in early life (Knudsen, 2004). As such, responsive stimulation interventions have shown to be less effective on child cognitive and language development outcomes after the first 1,000 days (e.g., Wint & Janssens, 2008). Therefore, our findings further support the idea that responsive stimulation interventions should be implemented early in life.

Implications

Overall, findings from the present study have two important implications for the implementation of a child-focused WASH intervention. First, our findings suggest that even a brief, single-session of a child-focused WASH intervention can produce measureable effects on caregiver WASH knowledge and practices. Given that our WASH intervention was low-cost and relatively easy to implement, it lends itself well to being scaled up to reach large populations with limited economic resources. In countries like Laos, where 80% of the population live in rural areas that are often inaccessible during the rainy season (UNICEF, 2014a), there are often yearlong service gaps for routine health and nutrition programs (Black et al., 2017). Thus, it is not often feasible to increase intervention dosage in such contexts. Our results show that a single session of a child-focused WASH intervention can initiate short-term change in caregiver knowledge and behaviors, and that, when combined with a responsive stimulation intervention, it can also initiate short-term change in child health and developmental outcomes. Thus, overall, our findings support the use of our approach in other similar contexts.

Second, our findings suggest that the combination of the child-focused WASH and responsive stimulation interventions generally yielded the best outcomes among caregivers and their children. Thus, our findings support the current movement to develop multi-sectoral approaches to more effectively address the multifaceted and interrelated causes of stunting and inequalities in child development (Clean, Nurtured, & Fed, 2017; Black & Dewey, 2014). Multi-sectoral programs have a distinct advantage in that they can be time- and cost-effective, which is ideal for use in low-resource settings. Furthermore, our findings also support the idea that multi-sectoral approaches will be most effective when intervention program messages are simplified and aligned to promote synergy (Stewart, 2016; Richter et al., 2017). For example, it is possible that because both of the interventions in our study were similarly designed to support *nurturing caregiving* practices (i.e., practices that support healthy child development), caregivers in the combined group may have become even more attuned to the needs of their children and/or become more motivated to support their children's healthy development (Richter et al., 2017). As such, these children may have received higher quality care from their parents through increased stimulation and better hygiene practices. Greater attunement to child needs/cues has also been linked to other areas of nurturing care, such as better recognizing when a child is hungry or needs medical attention (Lucas et al., 2017). A combination of any or all of these nurturing caregiving practices create a healthier environment for a child to thrive in (Britto et al., 2017). Therefore, our findings support the importance of scaling up multi-sectoral programming in LMICs to better promote child thriving.

Limitations

The current study had several limitations. First, although our findings support the acceptability and feasibility of the WASH intervention with Lao families, results should be interpreted with some caution. Participants were limited by the dichotomous (yes/no) rating options for the acceptability and feasibility questionnaire. Future evaluations should provide a Likert-scale for rating items and should also incorporate qualitative questions that allow caregivers to elaborate on their responses. Additionally, more objective measures, such as observational measures of caregiver WASH behaviors, could be used to better assess whether the intervention's behavior change targets are feasible.

A related limitation concerns the use of outcome measures that relied almost exclusively on caregiver reports rather than structured observation. Self-report relies on caregiver's recall and subjective interpretation and could also be influenced by social desirability bias. One of the measures that may have been especially susceptible to respondent-bias was the WASH practice questionnaire. There is extensive evidence documenting bias in self-report measures of hygiene practices, which includes the over-reporting of behaviors that are assumed to be "correct" (e.g., Curtis et al., 1993; Gittelsohn et al., 1997; Vindigni et al., 2011).

Furthermore, self-reported hygiene may be more prone to over-estimation *after* delivery of an intervention, as an intervention is likely to inform participants what "correct" behaviors the researchers are looking for (Vindigni et al., 2011). Although time and labor intensive, structured observation is thought to be the most valid and reliable method for measuring hygiene behaviors (Vindigni et al., 2011; Biran et al., 2008). Thus, the use of structured observation of hygiene behaviors in future studies would better help to aid our understanding of the effectiveness of child-focused WASH programs on hygiene behaviors.

The current study also did not include objective measures of intestinal functioning. Given the evidence that environmental enteric dysfunction (EED), rather than diarrhea, may be the primary mediator in the causal pathway between poor WASH and children's growth faltering (Humphrey, 2009), it would be beneficial for future studies to include measures of EED. For example, the current SHINE trial (Humphrey et al., 2015) is assessing EED through biomarkers of intestinal structure and function (i.e., inflammation, regeneration, absorption, and permeability). Such measures will help to further determine the mechanism by which child-focused WASH interventions impact child health and functioning.

We also readily acknowledge our study was limited by a small sample size. Due to the current study being underpowered, it is possible that we failed to detect important statistical differences between groups that may be clinically relevant. Furthermore, although our study detected significant effects for the WASH intervention, alone and in combination with the responsive stimulation intervention, larger studies will be needed to examine whether our findings are reproducible and applicable on a broader scale. In addition, our study may be limited in generalizability, as it is primarily representative of high risk families in rural villages in northern Laos. Sociocultural factors unique to our sample may not apply to other LMIC settings. However, given our findings from examining the effects of brief interventions used in a rural and disadvantaged context, we hope others will continue to expand on this work in other LMICs.

There were also several limitations related to the study design. First, the current study only used partial randomization. Specifically, villages were not able to be selected at random, and instead were co-selected by VTL and the Lao government based on location/accessibility, number of families with a child under the age of five years, and community-level access to WASH infrastructure. As a result, the findings from the current study may not be generalizable to Lao families who live in more remote locations with more limited access to WASH infrastructure. Furthermore, the design of the current study was limited by the fact that intervention groups were randomized at the village-level, rather than randomizing families to intervention groups within each village. Although we controlled for multiple sociodemographic variables to account for differences across villages in our analyses, it is possible that there are other village-level confounds that we were not able to address, including access to health care services, food security, etc. It will be important for future research studies to prioritize more rigorous study designs. For countries like Laos, it will be necessary to obtain buy-in from the national Ministry of Health to help make this possible. The current study also did not measure additional time points beyond one month post-intervention. It will be important for future studies to assess outcomes at additional time points post-intervention to examine whether the effects are sustained over longer periods of time.

Other limitations include potential iatrogenic effects from participating in the study and/or interventions. For example, participating in the study could have caused distress if a caregiver found the material difficult to understand or if it conflicted with their cultural or caregiving beliefs. Additionally, exposure to the WASH intervention could potentially create a heightened fear of disease among families. Furthermore, it is possible that in the long-term, the WASH intervention could produce unintended negative consequence on children's immune system development if children are too completely separated from their microbial surroundings. For example, it has been widely accepted that some exposure to germs and microorganisms in early childhood is helpful for immune system development (Hesselmar et al., 2013). Children have been found to be at a higher risk of developing autoimmune conditions, such as eczema and asthma, when they live in an overly sterile environment (Klass, 2017).

It may also be possible that the WASH intervention in the current study was limited by its reliance on manufactured soap. Given that access to soap may be limited in low-resource contexts (i.e., due to the prohibitive cost of purchasing soap and/or lack of access to commercial goods), future studies should address the barrier of soap cost with alternative solutions. Handwashing with soapy water (detergent powder plus water) is more cost-effective than bars of soap and just as microbiologically effective at removing fecal organisms from hands (Amin et al., 2014). There also may be more sustainable and local solutions that do not require the purchasing of soap or detergent. For example, in some studies, ash has been shown to be as effective as soap for removing bacteria from hands (Baker et al., 2014; Nizame et al., 2015).

Finally, the current study did not include a qualitative assessment of cultural factors that may have helped explained our findings. For example, there may have been important cultural beliefs and practices that explain why Lao caregivers may not have previously known about or discovered WASH and responsive stimulation behaviors for themselves. For instance, several qualitative studies across Western Africa have shown that mothers hold strong beliefs that young children are “pure” and that their feces are harmless, making it more likely that these mothers avoid washing their hands after handling their children’s feces or properly disposing of their children’s feces (Aluko et al., 2017; Scott et al., 2002). With respect to caregiving characteristics, it is often not typical for caregivers in countries with high child mortality rates to bond with their child out of fear that their child might not survive (UNICEF, 2014). Future studies should explore whether similar types of cultural beliefs or practices help explain why baseline WASH and responsive caregiving knowledge and practices is low among Lao caregivers in order to better understand how to improve knowledge and behavioral outcomes.

Conclusion

Eighty percent of the world’s infants live in underdeveloped countries where they are more likely to experience malnutrition, disease, and premature death due to poor WASH environments (Jensen et al., 2015). Given that only one in five people globally wash their hands with soap after defecation (Freeman et al., 2014), there is significant work to be done to educate and normalize the use of hygienic practices in everyday life. Child-focused WASH interventions have the potential to reduce the burden of feco-oral transmission among children in the first few years of life by helping to create improved environmental conditions that are necessary for children to thrive. Our findings suggest that even a brief, single-session of a child-focused WASH intervention can produce measureable effects on caregiver knowledge and behaviors, and, when combined with an early intervention targeting responsive and stimulating caregiving, the child-focused WASH intervention can yield additional positive short-term outcomes on child health and development. Therefore, the scaling up of child-focused WASH programs as part of multi-sectoral programming efforts (which, according to our findings, should include caregiver stimulation) is a critical and necessary step toward promoting sustainable economic and social development across the globe.

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