

CRITICAL ASSESSMENT OF THE IMPACT PATHWAYS OF COMMUNITY-
BASED INTERVENTIONS ON CHILD FEEDING AND HYGIENE BEHAVIORS IN
RURAL ZIMBABWE

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By

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CRITICAL ASSESSMENT OF THE IMPACT PATHWAYS OF COMMUNITY-
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Undernutrition remains prevalent in low- and middle-income countries and is an important indirect cause of childhood morbidity and mortality. Poor dietary intake and infection have been identified as the immediate causes of undernutrition in children. Evidence for efficacious interventions to improve dietary intake has been developed but their impact depends on the context in which they are implemented. Although ingestion of fecal microbes has been linked with infection, interventions to address this in children are limited and the available interventions do not address important pathways for fecal-oral contamination in children.

This dissertation comprises of three studies with an overall aim of assessing the impact of complementary feeding (CF) and water sanitation hygiene (WASH) interventions on maternal caregiving behaviors in rural Zimbabwe.

A CF feeding intervention that used behavior-change communication (BCC) to promote timely and adequate complementary feeding and provided a small-quantity, lipid-nutrient supplement (SQLNS) was evaluated using in-depth, multi-pass assessment of nutrient intake. We found that the CF intervention improved macro- and -micronutrient intake and increased the prevalence of children who consumed an adequate diet.

We used rigorous baby-observation methods to evaluate the impact of a comprehensive WASH intervention targeting fecal-oral contamination pathways in children less than 24 months old on key hygiene behaviors. We found that the WASH interventions reduced but did not eliminate exposure to vectors of fecal-oral microbial transmission in children.

We also investigated the emic perspectives on women's experiences with the different interventions and used ethnographic methods to identify facilitators and barriers to intervention uptake. This exploration revealed that caregiving decisions and intervention uptake are influenced by multiple factors. These factors included aspects of the caregiving environment, maternal capabilities, the intervention messages, and the person who delivered the intervention. Our results suggested that the perceived benefits of interventions on child health were the most important factor that drove women's caregiving decisions.

This dissertation used in-depth methods to evaluate child care interventions and provide comprehensive information on if, what, how and why interventions worked in the context of rural Zimbabwe. The results of this research show interventions that can be adapted and scaled up to improve caregiving behaviors around infant feeding and hygiene in rural communities.

BIOGRAPHICAL SKETCH

Dadirai Fundira was born in Kwekwe, a small town in central Zimbabwe. She attended high school at a public school in Kwekwe, then moved to Harare, the capital city of Zimbabwe to pursue a bachelor's degree in nutrition at the University of Zimbabwe. Throughout her studies, she looked for opportunities to put her studies into practice and worked as an intern in the Ministry of Health and Child Care in Zimbabwe in the national nutrition unit. After graduating from the University of Zimbabwe, she joined Zvitambo Institute for Maternal and Child Health Research where she had the opportunity to engage in research areas that ranged from HIV/AIDS, complementary feeding, breastfeeding and nutrition during pregnancy. During her time at ZVITAMBO, she co-led the formative research to develop community-based interventions to improve infant feeding and hygiene in rural communities. This experience inspired her to further her studies and obtain additional training in the area of maternal and child health. In 2014, Dadirai joined the program in international nutrition at Cornell, where she worked with Professor Rebecca Stoltzfus.

Dadirai's education is still in progress. During the course of her PhD training, she became interested in implementation science, particularly how to strengthen the implementation of evidence-based interventions to maximize impact in maternal and child health. Upon completion of her dissertation, Dadirai would like to be involved in implementation research science working with organizations that implement large-scale nutrition programs in low-income countries.

To Mary Ward Sisters, for giving me the foundation on which to build my dreams.

To my whole family, for always encouraging and supporting me.

To Meakin, for giving me my future

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LIST OF ABBREVIATIONS

BCC	Behavior change communication
BLUP	Best linear unbiased predictor
CDC	Center for Disease control
CF	Complementary feeding
CFU	colony forming units
CHW	Community health worker
CI	Confidence Interval
CV	Coefficient of variation
EAR	Estimated Average Requirement
EBF	Exclusive Breastfeeding
EED	Environmental Enteric Dysfunction
FAO	Food and Agriculture Organization
IQR	Interquartile range
IRR	Incidence rate ratio
LNS	Lipid nutrient supplement
MAD	Minimum acceptable diet
MDD	Minimum dietary diversity
MMF	Minimum meal frequency
MOHCC	Ministry of Health and Child Care
MPA	Mean Probability of Adequacy
OR	Odds Ratio
PA	Probability of Adequacy
POU	Point of use

RNIs	Recommended Nutrient Intake
SD	Standard Deviations
SES	Socio Economic Status
SHINE	Sanitation Hygiene Infant Nutrient Efficacy
SOC	Standard of Care
SQLNS	Small quantity lipid nutrient Supplement
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
US EPA	United States Environmental Protection Agency
VHW	Village health worker
WASH	Water and Sanitation/Hygiene
WHO	World Health Organization
ZDHS	Zimbabwe Demographic and health Survey

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CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

Background and Significance

The problem: Stunting and health in developing countries

Undernutrition is highly prevalent in low-income countries, particularly sub-Saharan Africa and Asia, and affects about a quarter of all children under the age of 5 years. [1], [2] Undernutrition including fetal growth restriction, stunting, wasting and micronutrient deficiencies is estimated to be the underlying cause of nearly 3.1 million deaths of children younger than 5 years annually worldwide, “representing about 45% of all deaths in this age group”. [3] In addition, it is also associated with impaired cognitive development, poor health outcomes, and decreased economic productivity. Significant efforts have been made to reduce under nutrition however the rates of stunting remain unacceptably high in low income countries. [3]

Stunting results from chronic malnutrition and the WHO defines stunting as having a height for age Z score that is below -2 standard deviations of the growth standard. [4] The prevalence of stunting in Africa is estimated at 35.6%, which is classified as high/serious by the WHO. [5] Moreover recent evidence show an upward trend in stunting rates in sub-Saharan Africa. [2] The impact of stunting on morbidity and mortality is small compared to other forms of malnutrition such as wasting [6], however stunting in the first 2 years of life has far reaching consequences throughout life. [6] Stunting has been shown to have permanent consequences, and results in shorter adult stature, delayed entry into school, poor performance and lower income later in life.

[2] Women who are stunted have also been shown to give birth to children who are stunted [7]–[9] and hence the negative impacts of stunting go beyond the individual to the next generation.

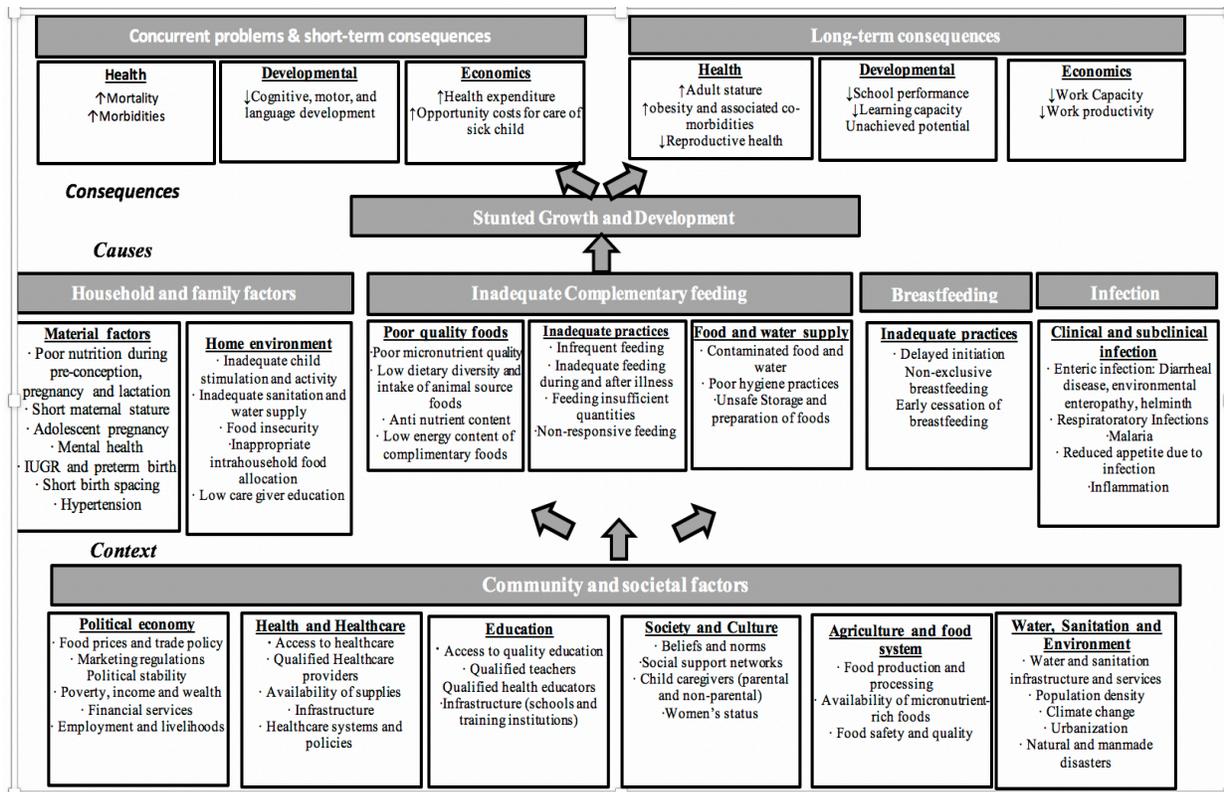
Causes of Stunting

The UNICEF conceptual framework on stunting was developed in 1990 and since then it has been widely used as a basis for research and intervention development for stunting reduction. [10] The framework outlines the causes of malnutrition on three levels: 1. Basic causes, which influence the quantity, quality and control of resources at the population level. 2. Underlying causes, which influence the ability of households and communities to access health services, quality care and food. 3. Immediate causes that influence the quality and quantity of food that an individual consumes and their susceptibility and rate of recovery from diseases. [3], [11] Several adaptations of the UNICEF conceptual framework have been developed for different purposes. About a decade after the UNICEF framework was published Engel et al, [12] published the first adaptation, with a focus on care. They defined care as the “provision in the household and the community of time, attention, and support to meet the physical, mental and social needs of the growing child and other household members” [12], or more simply, the practices that “translate food security and healthcare resources into a child’s wellbeing”. [12] The adaptation by Black and colleagues in 2008 highlighted both the short and long term consequences of stunting [6] and a later adaptation by the same group in 2013 [3] highlighted key evidence based interventions at each of the levels of the original UNICEF conceptual framework.

The World Health Organization’s (WHO) adaptation coupled stunting and development at the core of the framework and highlighted the shared causal pathways and timing for development. (figure 1.1) [13] This framework posits that although there has been a long standing consensus that stunted

growth is a risk factor for child development [14] they both in fact share the same causal pathways through biological and psychosocial deprivation, with long-term effects on physical stature and the brain's structural and functional capacity. Hence, they may be addressed by similar interventions. [13] In addition, the framework highlights the proximal causes of stunting and development as those related to household and family factors, breast feeding, inadequate complementary feeding and infection. Underlying all these is the community and societal factors which is an expansion of the basic and underlying causes in the original UNICEF conceptual framework. [13] This chapter will discuss the causes of stunting using the WHO adaptation

Figure 1.1: WHO conceptual framework for stunting



Household and family factors

Household and family factors contributing to stunting include peri conceptual conditions such as the mother's pre-pregnancy nutritional status, energy and nutrient intake as well as pregnancy physical and biological environment which can determine offspring growth and development.[15], [16] Maternal factors such as infection (e.g. malaria and HIV) [17], [18] adolescent pregnancy [19] short birthing space [20] and maternal mental health [21], [22] can also adversely affect uterine growth contributing to stunting. Within the home environment, factors such as poverty and caregiver education can affect caring determinants and have been associated with stunting.[23], [24]

Breast feeding

In addition to providing all of the infant's nutritional needs, breastmilk contains unparalleled immunological and anti-inflammatory properties that are important to protect developing children from illnesses and diseases. [25] Inadequate breastfeeding practices which includes delayed initiation of breastfeeding, not breastfeeding and non-exclusive breastfeeding have negative effects on developing children. This can be due to an increased risk in morbidity [6], [26] inadequate intake of energy, nutrient deficiencies and the absence of immunological factors provided by breastmilk which are essential for passive immunity.[27]

Complementary feeding

The WHO framework also emphasizes inadequate complementary feeding as a major cause of stunting. [13] Complementary feeding for infants refers to the timely introduction of safe and nutritionally rich foods in addition to breast-feeding, starting at about 6 months of age and continuing to 23 months of age or as long as breastfeeding continues. [3] Adequate complementary

feeding is a complex multi-dimensional construct encompassing a range of issues such as responsive feeding, food diversity, frequency or density. [28] The WHO framework outlines and emphasizes three aspects of complementary feeding important for stunting prevention, (1) poor quality food, (2) inadequate practices and (3) food and water safety. [13]

Poor quality complementary food resulting from poor dietary diversity or in the case of most low income countries, feeding food that is predominantly cereal based and dilute family foods may lead to inadequacies in micronutrient nutrition and energy intake. [29] Lack of animal-source foods [30]–[32] and intake of food with a high anti-nutrient content, such as phytates and polyphenols in the plant-based diets, also negatively affect the bioavailability of several micronutrients, such as vitamin A, zinc and iron, which are critical for growth and well-being. [29]

Inadequate complementary feeding practices include infrequent feeding, excessively dilute feeds with low energy density, inadequate feeding during illness, providing insufficient quantities of food and non-responsive feeding. [33]–[35] These complementary feeding practices limit the available nutrients for growth and also lead to increased rates of infection and hence are direct risk factors for stunting. [3]

The third category of complementary feeding is related primarily to the infection pathway to stunted growth through the provision of safe food and water. [13] Household-level hygiene practices as it relates to the handling and preparation of complementary food are important to reduce the risk of infection including diarrhea and other clinical and subclinical conditions that may impact growth. [36], [37] Practices such as hand washing, safe water source and storage, and ensuring a clean and safe environment for feeding are particularly important. [38], [39] Complementary foods storage practices and food preparation techniques may support microbial

growth and promote contamination. Unsafe food and water results in sustained exposure to enteric pathogens leading to significant detrimental effect on child growth and development. [38], [39]

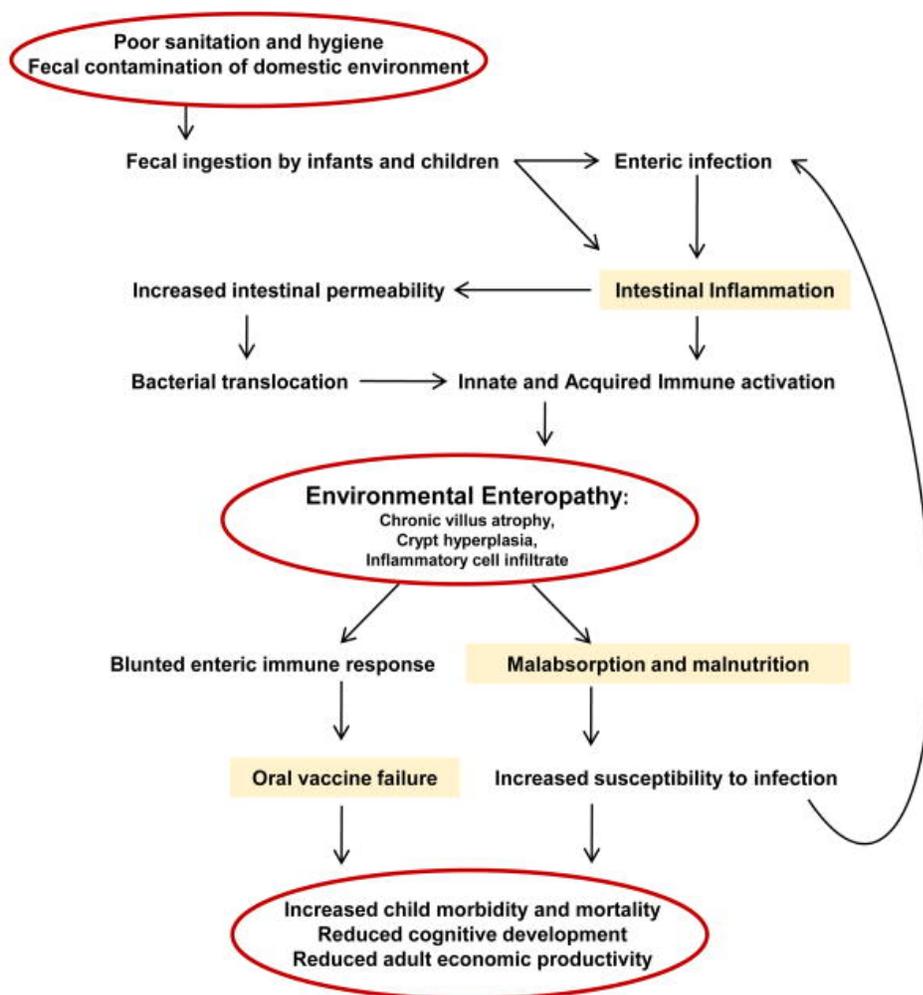
Infection

The cycle of malnutrition and infection has been well characterized. [40], [41] Malnutrition can make a child more susceptible to infection, inadequate dietary intake lowers the body's immunity making it more susceptible to invasion by pathogens and a sick child's nutrition status is affected by diarrhea, malabsorption and loss of appetite resulting in a vicious cycle that affects growth and development.[40], [41] Hence Infection can be a critical proximal cause of both stunted growth and development. [13]

Researchers have for decades assumed that the causal pathway for infection to stunting any hence growth benefits of improved Water Sanitation Hygiene (WASH) interventions are mediated through reduced diarrhea. [42] The link between WASH and diarrhea (the most studied and most frequent infectious disease in low income countries is based on the long-standing understanding that infection is central to the interactive relationship between disease and nutrition. [40] Recent reviews by Checkley et al and others have shown that the association between WASH and stunting is controversial and weak at best. [36], [43], [44] In a pooled analysis of nine studies, a higher cumulative burden of diarrhea before 24months was associated with greater odds of being stunted at 24 months. [36] Additional analyses of seven of these studies [44] revealed that the association between diarrhea burden and linear growth is small. The controversial findings between diarrhea and linear growth are attributed to catch-up growth after illness episodes. [43] [44] [45] The Lancet series in 2008 estimated that WASH interventions implemented at scale would reduce stunting by only 2.5%, when they modeled the impact through diarrhea.[46] The realization that most stunting

cannot be explained by poor diet or by diarrhea, nor completely reversed by optimized diet and reduced diarrhea has led researchers to reexamine papers published over the past several decades. Particularly papers that posited a linkage between unsanitary living environments leading to an acquired asymptomatic but chronic gut injury with systemic immune stimulation and poor growth. This has led to the hypothesis that the major underlying cause of stunting is a subclinical condition of the gut called environmental enteric dysfunction (EED). [47]

Figure 1.2: Environmental enteropathy to stunting.
Adapted from: Korpe and Petri, 2012



EED is not a new discovery; it was first described in people living in tropical climates and was first called tropical enteropathy. This dates back to the 1960s when an abnormal appearance of the

small bowel was observed in adults from low and middle-income countries. [48]–[52] The condition was characterized by decreased villous height, increased crypt depth, lymphocytic infiltration of the lamina propria, and increased intra-epithelial lymphocytes. In addition; most of these individuals had abnormalities in the absorptive function of the small bowel. [53] This condition was ubiquitous in people living in poor conditions however any explanation of ubiquity must take into account that the observation that the intestinal morphology of stillborn fetuses and newborns in these contexts are normal thereby demonstrating that this condition is acquired and not genetic. [48][42] Further evidence that this condition is acquired was shown in the studies conducted in peace corps volunteers who developed this condition while living in Pakistan but showed an improvement when they moved to cleaner environments [54]. As the condition became better understood it has been renamed environmental enteropathy and in more recent literature environmental enteric dysfunction to focus on functional changes that are characteristic of the condition. Although EED was widely reported in the 1970s and 1980s as an interesting phenomenon, there were few attempts to elucidate the mechanism of the disease, and the condition appeared to be almost forgotten over the next 20 years.[53] Studies done with children in the Gambia showed an association between markers of gut damage and stunting [55] which provided the first evidence linking stunting to EED.

In a viewpoint paper in 2009, Humphrey integrated this observation with the studies on tropical enteropathy that had been observed in the early 60s and put together the hypothesis that this subclinical condition is the major underlying cause of stunting in children living in contaminated environments.[47] Humphrey further hypothesized that ingestion of fecal microbes led to changes in the structure and function of the gut leading to growth impairment. This growth impairment is hypothesized to arise as a result of two overlapping pathways. First, partial villous atrophy results

in a reduced absorptive surface area and loss of digestive enzymes. This in turn results in maldigestion and malabsorption of nutrients. [42], [47], [56] Secondly, the gut is damaged and becomes a “leaky gut” allowing luminal contents to translocate into systemic circulation. Chronic exposure to microbes creates a condition of chronic immune activation, which (i) diverts nutrient resources (that are both scarce and in high demand) towards the metabolically expensive business of fighting infection (ii) suppress the growth hormone-IGF axis and inhibits bone growth remodeling, leading to growth impairment (iii) causes further damage to the intestinal mucosa thereby exacerbating the problem.[42], [47], [57] Several papers have since been published linking this condition to other problems of public health importance including anemia, [56] response to oral vaccine efficacy and HIV progression. [57]

Intervention efforts to address any of these causes of stunting highly depended on the context and societal factors. Although the original UNICEF framework highlights the importance of these broader factors under the basic causes of stunting, the more recent WHO framework goes a step further and itemizes to better inform context-specific considerations when developing intervention strategies for stunting reduction.

Intervention strategies that do not address community and societal factors may have limited success in changing practices.[58] For example, infrequent feeding may be as result of lack of food due political factors that lead to political instability, affect food prices or leads to high rates of poverty. Lack of dietary diversity and dilute feeds may be due to cultural beliefs, poor education or lack of diversity in the food system.[13] Other factors such as caregiver time constraints, self-efficacy and family involvement and support in childcare may affect the quality of care for children.[12][59] These examples highlight that barriers to interventions may exist at many levels

and will vary by context. This implies that for programs to be effective in preventing or reducing stunting, they should reach across disciplinary boundaries. [60] There has been a push for multi-disciplinary efforts to address stunting in the last few decades, with the promotion of nutrition specific and nutrition sensitive intervention to address both the direct causes of as well as community and societal factors determinants of stunting. [3], [61], [62]

Timing of growth faltering

As discussed above, stunting often begins very early in life, typically in utero, and generally continues during the first two post-natal years. The time of onset of suboptimal growth is important as it significantly affects the target group and optimal strategy of effective interventions to prevent childhood malnutrition. [63] Figure 1.3 shows that deficits in growth starts as early as 1 months of life, however most growth faltering occurs around the time mothers introduce complementary food and continues throughout infancy, about 4-24 months. Growth faltering levels off after 24 months and it appears there is no catch-up growth. [63] This period is also the time that children start to engage in normal exploratory play and mouthing behaviors including hand-to-mouth and object-to-mouth, and non-nutritive ingestion.[64] These behaviors can be pathways for fecal oral ingestion when living environments contaminated with enteric pathogens. [58]– [60], [61].

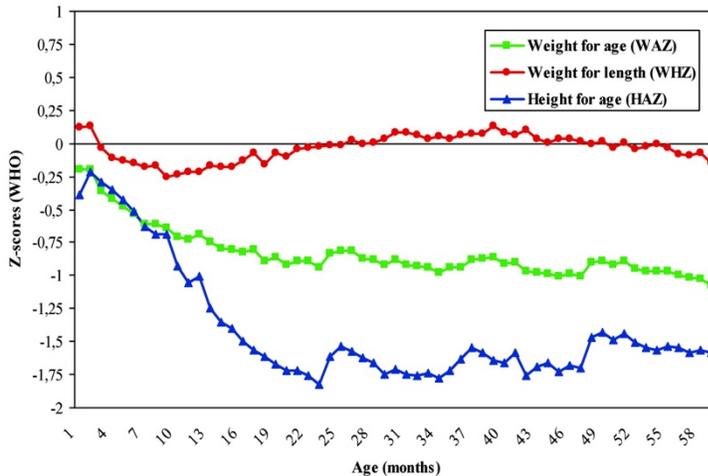


Figure 1.3: Timing of growth faltering. Victoria et al, 2010

This period hence highlights a key time for targeting interventions to prevent malnutrition. Major causes of growth faltering during this period are poor nutrient intake, clinical and subclinical infection. [69] Inadequate nutrient intake is due to poor quality of

diets containing inadequate macro and

micronutrients. [1] Complementary food in developing countries usually consist of thin staple porridges that do not contain adequate amounts of important nutrients. [3], [70], [71] Infant diets in this period are also mostly cereal-based foods with low bioavailability of micronutrients such as iron and zinc. [72], [73] These foods are often prepared and stored under unhygienic conditions [3], [74], [75] making children highly susceptible to infection. Children in highly contaminated environments are also exposed to high levels of enteric pathogens from their environments through exploratory play. In Zimbabwe, [38] Peru, [76] and Bangladesh, [77]–[79] babies were observed ingesting animal feces and soil through exploratory mouthing, and microbial analysis showed that these environments had high counts of *Escherichia coli*. [38], [77] Soil ingestion (geophagia) has been linked with intestinal helminth infections, [65], [80] growth faltering, [77], [78] and diarrhea [81]. In peri-urban Peru, [76] and rural Kenya, [76], [81] researchers used caregiver-reports to estimate child ingestion of feces and soil and found that the frequency of ingesting fomites was significantly associated with incident diarrhea among young children. Geophagia has also been associated with fecal indicators of environmental enteric dysfunction (EED) [76], [81]), which is hypothesized to be the major underlying cause of stunting in unhygienic environments. [77], [78] As discussed earlier, infection can limit growth by interacting synergistically with under nutrition

in a vicious cycle. Strategies to improve stunting should therefore address both the provision of safe and adequate diets as well as other strategies to prevent fecal oral contamination in children in the first 1000 days of life. [3]

Intervention strategies

The *Lancet* series in 2013 proposed a set of evidence-based interventions to address stunting.[3] They include nutrition-specific interventions that aim to improve dietary intake and minimize infection, nutrition-sensitive interventions that address the underlying community and societal determinants of malnutrition and also show ways that an enabling environment can be built to support interventions and programs.[3] Nutrition-specific interventions seek to ensure optimum growth by improving maternal and child nutrition. [2] Table 1.1 below summarize key evidence-based interventions and of the 10 interventions recommended as nutrition-specific 6 of them can be implemented through holistic complementary feeding intervention strategies that address all the 3 constructs of complementary feeding discussed earlier. Different strategies for (a) micronutrient supplementation or fortification (b) improving feeding behaviors and stimulation (c) dietary diversification (d) disease prevention and management and (e) treatment of severe acute malnutrition have been used over the last few decades. [2], [3]

Table 1.1: Evidence based intervention strategies [3]

Intervention type	Recommended Interventions
Nutrition-specific interventions	<ul style="list-style-type: none"> • Adolescent health and preconception nutrition • Maternal dietary supplementation • Micronutrient supplementation or fortification • Breast and complementary feeding • Dietary supplementation for children • Dietary diversification • Feeding behaviors and stimulation • Treatment of severe acute malnutrition • Disease prevention and management • Nutrition interventions in emergencies
Nutrition sensitive	<ul style="list-style-type: none"> • Agriculture and food security • Social safety nets • Early childhood development • Maternal mental health • Women’s empowerment • Child protection • Classroom education • Water sanitation • Health and family planning services
Building an enabling environment	<ul style="list-style-type: none"> • Rigorous evaluations • Advocacy strategies • Horizontal and vertical co ordination • Accountability, incentives regulation, legislation • Leadership programs • Capacity investments • Domestic resource mobilization

These strategies aimed to improve not only the quality and quantity of infant foods but also improve infant feeding practices as well. Some of these strategies include nutritional counseling or behavior change communication (BCC) to mothers designed to promote healthy feeding practices; provision of complementary food offering extra energy (with or without micronutrient fortification); and increasing energy density of complementary foods through simple technology (1,3,6,7). Reviews have been published looking at the impact of these various complementary feeding interventions strategies [3], [71], [75], [84] on growth and other health outcomes including morbidity, mortality and anemia.

Dewey and Adu-Afarwah 2008 [71] reviewed complementary feeding interventions from 1998 through 2007 to assess their effects on growth, micronutrient status, morbidity and mortality and child development. They included studies using BCC, food supplementation plus BCC, food fortification and techniques to increase energy density. Their results suggested positive impact on linear growth through the provision of supplementary complementary food and BCC under well-controlled situations. They concluded that all these interventions combined have a modest effect on weight and length growth of about ~ 0.25 SD. [71]

Imdad et al. 2011 [75] reviewed 17 studies that evaluated the impact of provision of complementary foods with or without BCC and of BCC alone on growth. Their results showed that both these interventions resulted in increased weight [WMD 0.34 SD, 95% CI 0.11- 0.56 and 0.30 SD, 95 % CI 0.05-0.54 respectively) and linear growth [WMD 0.26 SD, 95 % CI 0.08-0.43 and 0.21 SD, 95 % CI 0.01-0.41 respectively]. Pooled results for actual increase in weight in kilograms and length in centimeters showed that provision of appropriate complementary foods and BCC resulted in an extra gain of 0.25 kg (± 0.18) in weight and 0.54 cm (± 0.38) in height in children aged 6-24 months. Their results demonstrated that both provision of appropriate CF (with or without BCC) and BCC alone have a significant impact on improving weight and linear growth.

Lassi et al 2015 [83] reviewed 16 studies and programs that looked at the effect of complementary feeding with or without fortified supplements and BCC on growth at 2 years. Their results showed that BCC improved height for age z-score HAZ (SMD: 0.23; 95% CI: 0.09, 0.36), WAZ (SMD 0.16, 95% CI: 0.05, 0.27), and significantly reduced the rates of stunting (RR 0.71; 95% CI: 0.56, 0.91). However, they reported that there was no significant impact for height and weight gain.

They conducted a subgroup analysis to distinguish the impact in food secure and food insecure regions and showed that in food secure populations BCC on complementary feeding had a significant impact on height gain, HAZ scores, and weight gain, however, stunting reduced non-significantly. In food insecure population, BCC alone significantly improved HAZ scores, WAZ scores and significantly reduced the rates of stunting, while provision of complementary food with or without BCC improved HAZ and WAZ scores significantly. This review showed that complementary feeding interventions have a potential to improve the nutritional status of children in developing countries. The authors highlighted the need for more research on large-scale, high quality randomized controlled trials to assess the impact of these interventions on growth and morbidity in children 6-24 months of age. They also recommended that BCC should be combined with provision of complementary foods that are affordable, particularly for children in food insecure countries.

Kristjansson et al, 2015 [84] also conducted a meta-analysis of 32 studies and programs assessing the impact of complementary feeding interventions on growth and development in children less than 2 years. Their results showed that provision of supplementary complementary food has positive impact on growth in low and middle-income countries. Meta-analysis of the randomized control trials showed that supplemented children gained an average of 0.12 kg more than controls over six months (95% confidence interval (CI) 0.05 to 0.18, 9 trials, 1057 participants, moderate quality evidence). They also showed that supplemented children grew an average of 0.27 cm more over 6 months than those who were not supplemented (95% CI 0.07 to 0.48, 1463 participants, moderate quality evidence). Their results also showed benefits for weight-for-age z-scores and height-for-age z-scores but not for weight-for-height z-scores. In this review they also looked at the results from 3 trials that they classified as “well implemented” trials. The pooled results from

these “well implemented” trials suggested that implementation is key to the impact of complementary feeding interventions showing greater height gain, 0.76 cm 95% confidence interval 0.30 to 1.22, for these 3 trials compared to the 0.27 cm (0.07, 0.48) and 0.43 cm (0.19, 0.65) height gain reported in the other 9 ‘poorly implemented trials’ in their review and the 11 studies reported by Lassi et al respectively.

Panjwani and Heidkamp, 2017 [85] recently published a review of the impact of complementary feeding interventions on linear growth [length-for-age z score (LAZ)] and ponderal [weight-for-length z score (WLZ)] growth of children aged 6–23 months [85]. Their results showed a small benefit of BCC on linear growth or stunting in food secure populations [Length for age z score (LAZ) standardized mean difference (SMD): 0.11; 95% CI: 0.01, 0.22] but not on ponderal growth. In food insecure populations provision of some kind of complementary food supplement with or without BCC had an impact on both length-for-age z score (LAZ) (SMD: 0.08; 95% CI: 0.04, 0.13) and (SMD: 0.05; 95% CI: 0.01, 0.08).[85]

Several approaches to provide supplements and or fortified foods have been implemented. [82], [84], [86] ‘Home fortification’ [87], [88] has been used as a potential strategy for targeted delivery of specific nutrients to infants and young children.[87], [88] Small quantity lipid based nutrient supplements (SQLNS) are one example of a home fortificant that has been gaining interest because of its potential to provide both micronutrients and energy in small quantities of the supplement. The term ‘lipid-based nutrient supplements’ (LNS) refers generically to a range of fortified, lipid-based products, including products like ready-to-use therapeutic foods (RUTF) (a large daily ration with relatively low micronutrient concentration) as well as highly concentrated supplements (1–4 teaspoons/day, providing <100 kcal/day) to be used for ‘point-of-use’ fortification. [89] LNS are

easy for infants to consume (unlike multiple micronutrient supplements in pill form. [89], [90] LNS differ from other supplements such as multiple micronutrient powders because they are produced in a food base and deliver energy, protein and essential fatty acids (EFA), as well as a wider range of micronutrients than micronutrient powders, including the macro minerals required for growth.[90]

Results from several reviews of multiple micronutrient use have also not shown impact on linear growth [88]. It has been suggested this may be because micronutrients alone may not be sufficient to stimulate linear growth or that the range or amount of micronutrients provided in multiple micronutrient powders has not been sufficient. [74] Provision of other complementary foods, such as corn soy blend, although they can successfully provide adequate nutrients have limitations in that they require preparation and unhygienic handling can make infants susceptible to infection leading to growth faltering.[91], [92] In addition, the high quantities required to meet the nutrient requirements when using complementary food such as corn soy blend may result in displacement of breast milk in the diet. [91] LNS, on the other hand, are very energy dense and can supply approximately 100 kcal plus the recommended nutrient intake of micronutrients in a small 20 g dose. [89], [90] LNS has high lipid content and hence the water activity (amount of water available to microorganisms in the product) is low thus makes it difficult for bacteria to grow in it. [90] The high energy density of LNS would enable mothers to feed smaller quantities fewer times a day than the same amount of energy from other supplements such as corn soy blend and thus possibly prevent a displacement of breast milk in the diet. [90] LNS is typically provided in small quantities of 20g or less and from this point will be referred to as small quantity lipid nutrient supplements (SQLNS) in this document.

Table 1.2 summarizes some of the studies that have reported the impact of SQLNS on growth in children 6-24 months of age. Results are conflicting with some studies showing potential impact while others show no impact. The duration of the intervention and the comparison group in each of these studies was different making it hard to draw any conclusions. Hence the impact of SQLNS on growth remains unclear.

Table 1.2: Summary of efficacy trials assessing the effect of LNS on linear growth

Study site	Study design	Results and conclusions
Malawi [93] Ashorn et al, 2015	<p>Study population:</p> <ul style="list-style-type: none"> • Children 6-18 months • (n=869) <p>3 treatment groups</p> <ul style="list-style-type: none"> • Mother: IFA, Child: no supplement • Mother: MMN, Child: no supplement • SQ-LNS (20 g/d) (mother and child) <p>Primary outcome:</p> <ul style="list-style-type: none"> • Length at 18months 	<ul style="list-style-type: none"> • At age 18 months, the mean length in the IFA, MMN and SQ-LNS groups were 77.0, 76.9 and 76.8 cm (P = 0.90), respectively, • Prevalence of stunting was 32.7, 35.6 and 37.9 % (P = 0.54), respectively • Overall no difference between groups at 18 months
Malawi [94] Maleta et al, 2015	<p>Study population:</p> <ul style="list-style-type: none"> • Children 6-18months • n=1932 <p>Treatment arms groups</p> <ul style="list-style-type: none"> • Milk-SQ-LNS 1 (10 g/d) • Milk-SQ-LNS 2 (20 g/d) • Milk-SQ-LNS 3 (40 g/d) • Milk-free-SQ-LNS 1 (20 g/d) • Milk-free-SQ-LNS 1 (40 g/d) • Control: no supplement <p>Primary outcome</p> <ul style="list-style-type: none"> • LAZ at 18 months of age 	<ul style="list-style-type: none"> • Mean (SD) length and LAZ changes were 13.0 (2.1) cm and -0.45 (0.77) z-score units, respectively; with no difference between the six groups ((P = 0.66 for length and P = 0.74 for LAZ). • The difference in mean LAZ change in the no-milk LNS group compared with the milk LNS group was -0.02 (95 % CI -0.10, 0.06; P = 0.72) • No difference in growth between intervention and control groups
Burkina Faso [95] Hess et al, 2015	<p>Study population:</p> <ul style="list-style-type: none"> • Children 9-18months • n= 3220 <p>Intervention cohorts (IC)</p> <ul style="list-style-type: none"> • SQ-LNS without zinc (20 g/d), placebo tablet*; • SQ-LNS with 5 mg zinc (20 g/d), placebo tablet* • SQ-LNS with 10 mg zinc (20 g/d), placebo tablet* 	<ul style="list-style-type: none"> • At age 18 months, the length was significantly greater in IC to (NIC) (77.7 (3.0) v. 76.9 (3.4) cm; P < 0.001) and • stunting prevalence was significantly lower in IC (29.3 %) than NIC (39.3 %; P < 0.0001), but did not differ by intervention group within the IC • change in hemoglobin was greater in IC than NIC (+8 vs -1g/L, p<0.0001), but 79.1% of IC were still anemic (vs. 91.1% in NIC). • SQ-LNS with or without zinc, provided along with malaria and diarrhea treatment, significantly increased growth and reduced stunting and anemia

	<ul style="list-style-type: none"> • SQ-LNS without zinc, 5 mg zinc tablet* 	
	Non-Intervention cohorts (NIC)	
	<ul style="list-style-type: none"> • No supplements, illness surveillance or treatment 	
	Primary outcome	
	<ul style="list-style-type: none"> • LAZ • Stunting • Anemia 	
Haiti (urban slums) [96] Iannotti et al, 2014	<p>Study population:</p> <ul style="list-style-type: none"> • Children 6-11 months • n=589 <p>Treatment groups</p> <ul style="list-style-type: none"> • 3 months SQ-LNS (20 g/d) • 6 months SQ-LNS (20 g/d) • Control <p>Primary outcome</p> <ul style="list-style-type: none"> • LAZ 	<ul style="list-style-type: none"> • LNS supplementation for 6 mo significantly increased the length-for-age z score (\pmSE) by 0.13 ± 0.05 and the weight-for-age z score by 0.12 ± 0.02 compared with in the control group after adjustment for child age ($P < 0.001$) SQ-LNS provided from 6 to 12 months resulted in increased length. • The effects were sustained 6 months' post-intervention, compared to a control group
Malawi [97] Mangani et al, 2013	<p>Study population:</p> <ul style="list-style-type: none"> • Children 6-18 months • n=840 <p>Treatment groups</p> <ul style="list-style-type: none"> • Milk-SQ-LNS (20 g/d){ • Soya-SQ-LNS (20 g/d) • CSB • Control <p>Primary outcome</p> <ul style="list-style-type: none"> • LAZ • Stunting 	<ul style="list-style-type: none"> • Between 9-12 months of age the mean change of LAZ was 0.15, 0.02, 0.12 and 0.18 ($p=0.0045$) for control milk-LNS, soya LNS and CSB groups respectively. • The incidence of severe stunting was 11.8%, 8.2%, 9.1% and 15.5% ($P = 0.098$) and that of very severe stunting 7.4%, 2.9%, 8.0% and 6.4% ($P = 0.138$) in control, milk-LNS, soy-LNS and CSB groups, respectively. • Exploratory analyses suggest that provision of milk-SQ-LNS, but not soya-SQ-LNS promotes linear growth among at-risk infants mainly between 9 and 12 months of age
Malawi [98] Phuka et al, 2009	<p>Study population:</p> <ul style="list-style-type: none"> • Children 6-12 months • n=182 <p>Treatment groups</p> <ul style="list-style-type: none"> • CSB 	<ul style="list-style-type: none"> • The cumulative 36-month incidence of severe stunting was 19.6 % in CSB, 3.6 % in SQ-LNS 1 and 10.3 % in SQ-LNS 2 groups ($P = 0.03$). • Differences in LAZ observed at age 10–18 months

Ghana [99]
 Adu-Afarwuah et al,
 2007

- SQ-LNS 1 (50 g/d)
- SQ-LNS 2 (25 g/d)
- Control group

Primary outcome

- LAZ
- Stunting
- WAZ

Study population:

- Children 6-12months
- n=313

Treatment groups

- Srinkles Powder SP
- Nutritab (NT) tablets
- SQ-LNS (Nutributter (20 g/d)

Primary outcome

- LAZ

- Provision of 50 g/d SQ-LNS from 6 to 18 months of age showed a tendency to reduce the incidence of severe stunting, particularly for children with baseline LAZ below the median
- At 12 mo, after control for initial size, the NB group had a significantly greater weight-for-age z score (WAZ) (-0.49 +/- 0.54) and length-for-age z score (LAZ) (-0.20 +/- 0.54) than did the NT group (WAZ: -0.67 +/- 0.54; LAZ: -0.39 +/- 0.54) and the NT and SP groups combined (WAZ: -0.65 +/- 0.54; LAZ: -0.38 +/- 0.54); the difference with the NI group (WAZ: -0.74 +/- 1.1; LAZ: -0.40 +/- 1.0) was not significant. A lower percentage of the NI infants (25%) than of the intervention groups (SP: 39%; NT: 36%; NB: 49%) could walk independently by 12 mo.
- All 3 supplements had positive effects on motor milestone acquisition by 12 mo compared with no intervention, but only NB affected growth.

WASH interventions were also proposed by the 2013 *Lancet* series [3] as important nutrition sensitive intervention to address stunting. WASH interventions have the primary objective of preventing fecal microbial transmission and preventing the ingestion of harmful microbes.[42] Pathways for fecal microbial transmission are either direct through contaminated hands or indirect via the contamination of food and water.

Several strategies have been used to implement WASH interventions and the majority have focused mainly on household and community behaviors with the aim of preventing stools from getting into the domestic living area, rather than prevent pathogens in the environment from being ingested. [100] These intervention strategies have also focused on human feces, which is an important reservoir of a range of pathogenic bacteria that can cause diarrhea, EED and other morbidities in children.[101] However, there has been a growing body of evidence suggesting that exposure of children and their caregivers to animal feces is also an important risk factor for clinical and subclinical infections.[102], [103]

Evidence of the impact of WASH on stunting is limited and when available the results are inconsistent. [104] Dangour et al 2013, [105] reviewed 14 randomized control trials (RCTs) that included WASH interventions either singly or in combination. Their results which included the analysis of data from 4,627 children showed no evidence of an effect of WASH interventions on weight-for-age z-score (MD 0.05; 95% CI -0.01 to 0.12) and weight-for-height z-score (MD 0.02; 95% CI -0.07 to 0.11). They also showed a borderline statistically significant effect of WASH interventions on height-for-age z-score (MD 0.08; 95% CI 0.00 to 0.16). They also reported that none of the studies used high quality

methodological approaches and that adherence to study interventions was reported in only two cluster-randomized controlled trials and ranged from low (< 35%) to high (> 90%).

Freeman et al, 2017 [106] also recently conducted a meta-analysis of the impact of WASH interventions. Their results suggested that overall, WASH interventions were protective against diarrhea, active trachoma, schistosomiasis, and height-for-age. They however showed no effect for other anthropometric outcomes. They also reported that there was high heterogeneity and the evidence was generally of poor quality. The studies did not report adherence and the interventions were not rigorously implemented. They recommended more research that “rigorously describes sanitation implementation and type of sanitation interventions.” [106]

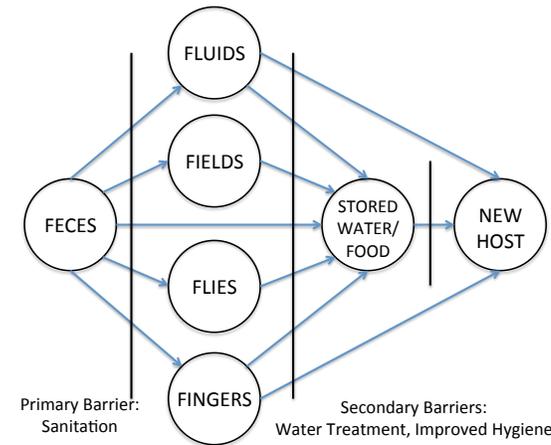
In contrast to this evidence from RCTs, evidence from observational studies suggest a strong association between WASH and child health and nutrition. A review by Fink and colleagues, 2011 showed that WASH interventions were associated with lower mortality (OR = 0.77, 95% CI 0.68-0.86), a lower risk of child diarrhea (OR = 0.87, 95% CI 0.85-0.90) and a lower risk of mild or severe stunting (OR = 0.73, 95% CI 0.71-0.75). Several observational studies have also shown this strong protective effect of WASH interventions on stunting [107]–[109]

Gaps in the literature

Although there is substantial evidence on evidence-based interventions to improve complementary feeding and reduce fecal oral microbial ingestion, a number of gaps still remain.

First, the available evidence for current WASH interventions to prevent ingestion of microbes show that interventions are driven by the F diagram shown in figure 1.4.[39] and

Figure 1.4: The F diagram



have focused primarily on human feces particularly preventing human feces from entering living environments rather than prevent pathogens in the environment from being ingested. [100]

Intervention strategies

include: provision of latrines and safe water sources, hand washing with soap, water treatment, hygiene handling of complementary feeding as well as fly control. It is important to note that the importance of each of these intervention strategies is dependent on pathogens, settings and the target population. Effective interventions need to address the predominant transmission routes for the target population and context. Specifically, WASH interventions seeking to prevent clinical and subclinical infection in children should address specific pathways through which fecal oral microbial transmission occurs in the first two years of a child's life. [42]

Observation studies in babies [38] [77] [76] have shown that the primary pathway for fecal-oral contamination in babies is through exploratory play and mouthing, specifically the ingestion of contaminated soil, chicken feces and mouthing of contaminated objects. WASH Interventions are usually targeted at the household and community level and do not

address these routes of fecal oral contamination in children. Available WASH interventions also do not adequately address hand washing of baby hands and handling of baby feces. [39] In addition available WASH interventions are not targeted for the developmental stage in babies for which they are most relevant. [42], [110] WASH interventions have also focused primarily on human feces as an important reservoir for a range of pathogenic bacteria important for child health outcomes. [101] However research in the last few years seem to suggest that although human feces is an important cause of diarrheal illnesses in young children, animal feces may also expose children to non-pathogenic bacteria that may be important in the etiology of EED.[42], [47], [111] There is a need for WASH interventions that focus more on animal feces as the exposure to animal feces, particularly for children, is more widespread than exposure to human feces. [102], [112]

For complementary feeding (CF) interventions reviews of available evidence makes it clear that (1) impact of complementary feeding interventions is dependent on the context (2) BCC may have a small impact in food secure but not food insecure regions and (3) in food insecure regions there may be greater impact on growth if BCC is coupled with the provision of some form of complementary food or supplement. However, when intervention strategies used both BCC and provision of supplements, the studies usually do not report which aspects of the intervention is effective in the different contexts.[85] Also due to the use of simple survey based tools, data on the impact of intervention strategies on actual dietary intake is also limited.

Another potential bottleneck to realizing maximum impacts for CF feeding and WASH interventions is participation of the caregiver and their engagement with the intervention.

The UNICEF extended framework on malnutrition recognized care as a critical underlying factor that is important in child growth. [12] Caregiving is dynamic and is influenced by various social supports and constraints, including a caregiver's experiences, interactions with her child and the caregiving environment.[113]. Child health interventions are delivered and expected to work within this dynamic context. However, there is very limited evidence on how caregivers make decisions about intervention uptake or strategies to address how to effectively support women when they do take up interventions.

This research contributed to these gaps in knowledge by evaluating the impact of (1) a WASH intervention that targeted fecal oral contamination in children and (2) a CF intervention that provided both BCC and SQLNS to improve nutrient intake. This work also provides an in-depth assessment of household factors that influence maternal caregiving behaviors and identify factors that influence intervention impact.

Study context

The Zimbabwean context

This dissertation research was conducted in two rural districts in central Zimbabwe. Political instability and poor governance for close to 3 decades in the country has left Zimbabwe amongst the poorest countries in the world and it ranks 156 of 186 countries on the UNDP Human Developmental Index. [114]

About 80% of the country's population live below the poverty line and the poorest (the majority of whom are in rural areas) are estimated to be living at \$1.99 per day. [115], [116] The agriculture sector is the backbone of the Zimbabwean economy and it contributes

5-20% of GDP. However political instability in the last decade has seen a decrease in productivity of the agriculture sector and an increase in food insecurity.[115]. The Zimbabwe Vulnerability Assessment Committee estimated that 4.1 million (42 percent of the rural population) was food insecure in 2017. [116] 97 percent in urban households and 69 percent in rural households have access to safe water and 46% of urban and 32 5% or rural household have an improved latrine. [117]

Just over a quarter (27 percent) of children under age 5 are stunted, 3 percent are wasted (thin for their height); 8 percent are underweight (thin for their age); and 6 percent are overweight (heavy for their height).[118] The UNICEF multiple indicators survey in 2015 also collected data on different complementary feeding practices including minimum dietary diversity (MDD), minimum meal frequency (MMF) and minimum acceptable diet (MAD). MDD is defined as the proportion of children 6-18 months who received foods from 4 or more food groups during the previous day. MMF is the proportion of breastfed and non-breastfed children 6-18 months who received solid, semi solid or soft foods the minimum number of times or more during the previous day. The third indicator MAD is defined as proportion of children 6-18 months of age who had at least the minimum dietary diversity and minimum meal frequency during the previous day. [119] In the 2015 UNICEF multiple indicators survey [118], MMF was 68%, MDD 27% and MAD only 12%. The DHS in the same year recorded that most of the food fed to children were thin cereal-based porridges commonly prepared as weaning foods in both urban and rural areas and this are generally energy insufficient and also lack essential micronutrients including vitamin A, iron and zinc. [117]

The Sanitation Hygiene Nutrition Efficacy (SHINE) study

This research was carried out within the context of the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) Trial. SHINE was a 2X2 factorial, cluster-randomized, community-based trial conducted in 2 rural districts of Zimbabwe between 2012 and 2016. [120] The primary aims of the SHINE study were to assess the independent and combined effects of a package of interventions to improve household water, sanitation and hygiene (WASH) and a package of interventions to improve complementary feeding (CF) practices, when these interventions were initiated during early pregnancy among HIV negative women and continued through 18 months postpartum, on stunting and anemia of rural Zimbabwean infants at 18 months of age. [120]

The Program Evaluation Context

The earlier part of this document discussed several intervention strategies for reduction of stunting and other health problems for children less than 24 months that showed mixed results. There is a substantial knowledge and experience gap around the translation of evidence-based recommendations into feasible interventions that improve infant growth outcomes in low income countries. [121]

This dissertation research aimed to contribute towards filling that gap by conducting a scientifically rigorous evaluation of evidence-based nutrition specific and nutrition sensitive interventions. This research evaluated the impact of both the WASH and CF interventions on relevant behaviors to inform the process evaluation embedded within the SHINE trial [122]. For this dissertation research an evaluation approach guided by program theory was used to distinguish the ways interventions contributed (or failed to contribute)

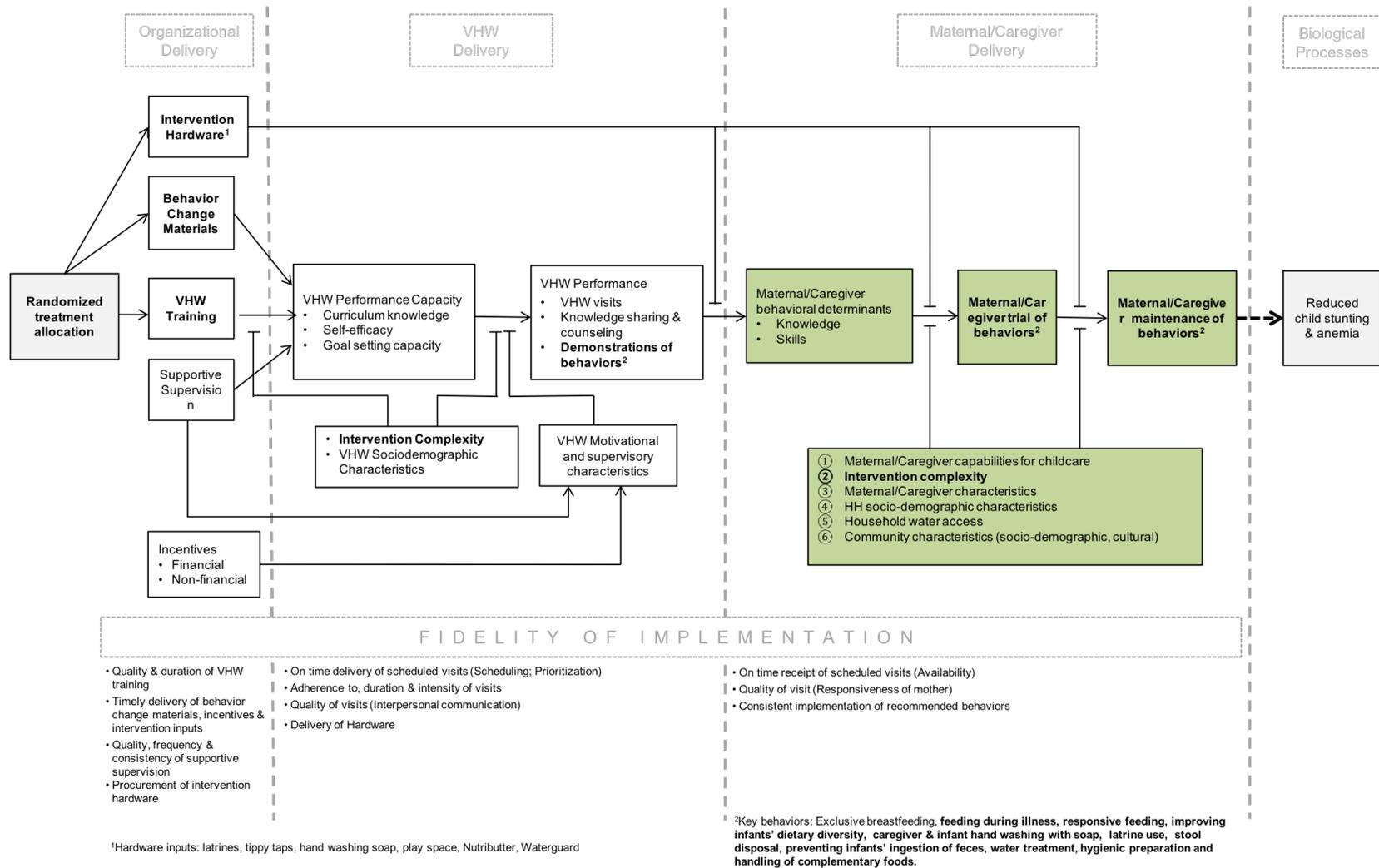
to intended outcomes. Specifically, this research aimed to understand what worked, how it worked and explore the different factors that may have contributed to this.

Study participants were women in Zimbabwe enrolled into the SHINE trial. SHINE utilized community health workers (locally known as village health workers (VHW)) who are part of the health delivery system to deliver the behavior change component of the interventions. [120], [122] The WASH intervention package included a latrine (if a functional one was not available already), two handwashing stations, a monthly supply of handwashing soap and the promotion of 5 key behaviors: a) proper disposal of animal and human feces, b) handwashing with soap after fecal contact, c) point-of-use chlorination of drinking water, d) protecting children from ingestion of dirt and feces, and e) feeding baby freshly prepared foods, or properly reheating leftover food. The CF intervention package aimed to improve growth by ensuring that children consume an adequate diet as a result of improving infant feeding practices. The intervention consisted of BCC messages around continued breastfeeding, feeding a balanced diverse diet and how to feed a child during illness. The BCC messages started from 6 months of age to 12 months and participants were also provided with a daily provision of 20g of a SQLNS that provided additional energy and a full complement of micronutrients up to 18months.

The SHINE program impact pathway (PIP), which was published in depth elsewhere [122] and is summarized in figure 1.5, outlines the pathway from the provision of interventions to health outcomes. The primary aim of the SHINE trial is mediated by a change in infant feeding and hygiene behaviors relevant for children less than 18 months. As such the data collected for this study provided in-depth information on the adoption of relevant behaviors

and strengthened the causal inferences for the study. Studies often do not assess how a program achieved its impact including the various contextual and delivery-related factors that may have contributed to the program outcomes.[121], [123], [124] As a result, we often do not understand what aspects of interventions work and why some intervention can prove to be effective in one setting or context but fail to produce the same impact when in a different context. In addition to assessing the specific behaviors that were improved by the interventions this dissertation also explored contextual factors from the caregiver's perspective to identify factors that are important for uptake and sustained use of WASH and CF interventions

Figure 1.5: SHINE program impact pathway (PIP)



Research Aims

The overall goal of this dissertation is to provide insight into nutrition-sensitive and nutrition-specific interventions, particularly what worked and how it worked. This work also highlights the potential for making nutrition-specific and -sensitive interventions more effective by exploring important contextual factors from the caregiver's perspectives. The specific research aims are discussed in the following chapters:

Chapter 2 evaluates the impact of a nutrition specific intervention that promoted timely and adequate complementary feeding and provided a small quantity lipid based nutrient supplement (SQLNS) on nutrient intake. Specifically, we utilized the randomized design of the SHINE trial and in-depth methods to assess if the CF intervention was effective in improving:

- Intake of key macro- and micro-nutrients
- The prevalence of consuming adequate amounts of specific macro and micro nutrients
- Key infant feeding practices

Chapter 3 also uses the randomized design of the primary SHINE trial and in-depth baby observation methods to evaluate the impact of a comprehensive WASH intervention targeting fecal oral contamination pathways in children less than 24 months. Specifically, we assessed if the WASH intervention

- Reduced infant exposure to vectors of fecal oral contamination
- Improved infant handwashing
- Impacted caregiver response to infant mouthing of visibly dirty objects.
- Impact caregiver behaviors around cleaning infant play environments

Chapter 4 provides a detailed description of women's understanding of their own caregiving environment, competences and caregiving priorities. It also explores the mother's experiences with the different interventions to identify facilitators and barriers to intervention uptake. Using ethnographic methods, we explore:

1. The mother's perspectives on caregiving and their own evaluation of their caregiving competence
2. The caregiver's perspective of their caregiving environment and factors that they consider important within that environment
3. How the interventions interacted with the mother's caregiving environment and identify factors that influenced the mother's caregiving decisions
4. Identifying motivators/facilitators and barriers to intervention uptake that may be important for nutrition specific and nutrition sensitive interventions.

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CHAPTER 2

IMPACT OF A COMPLEMENTARY FEEDING (CF) INTERVENTION ON NUTRIENT INTAKE AND PREVALENCE OF ADEQUATE DIET AMONG 12-MONTH-OLD INFANTS IN RURAL ZIMBABWE

Abstract

Background: Childhood undernutrition remains prevalent and is an important indirect cause of morbidity and mortality in children less than five years. The period of complementary feeding (6-24months) is the time associated with most undernutrition in children. Poor complementary feeding practices that contribute to infant undernutrition include feeding foods of low nutrient density, low feeding frequency and not feeding nutrient rich animal foods. We evaluated a complementary feeding (CF) intervention which included behavior change communication (BCC) and provision of a small quantity lipid nutrient supplement (SQLNS) and was implemented as part of the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) study in rural Zimbabwe. **Objectives:** We aimed to assess the impact of the CF intervention on (1) intake of key macro- and micro-nutrients, (2) the prevalence of consuming adequate amounts of specific macro- and micro-nutrients and (3) key infant feeding practices **Methods:** We conducted a sub-study within the SHINE trial. SHINE was a cluster randomized 2x2 factorial trial to determine the individual and combined effects of a CF and water sanitation hygiene (WASH) intervention on stunting and anemia among infants in rural Zimbabwe. We conducted multi-pass 24-hour dietary recalls among a randomly selected sample of 195 caregivers when their infants were 12 months old. The CF (n=100) group was compared with the non-CF group (n=95) for differences in macro- and micronutrients intake including and not including the SQLNS. Prevalence of dietary adequacy was assessed using the measurement-error method and

compared between the CF and non-CF group. **Results:** Dietary energy intake was significantly ($p=0.021$) higher among CF 543.4kcal (398.5 SD) /day) than non-CF 430.3 (267.7 SD) /day) infants. The CF group also had significantly (all $p<0.001$) higher intakes of micronutrients that included vitamin A, folate, calcium, iron and zinc. The prevalence of dietary adequacy was significantly higher in the CF intervention arm for all nutrients. Intakes of all macro- and micronutrients from non-supplement foods did not differ significantly between the CF groups, which suggests that the SQLNS provided all the nutritional benefit and did not replace non-SQLNS food intake. **Conclusion:** The CF intervention improved macro- and micronutrient intake and prevalence of adequate diet.

Introduction

Rates of stunting and wasting are high during the complementary feeding period (6-24 months) among children in low-income and middle-income countries. [1] Undernutrition during childhood has been attributed as the underlying cause of over 3 million deaths among children under the age of 5 years and has been shown to be associated with lasting negative consequences throughout life that undermine the long-term developmental capacities of individuals.[2], [3] Poor complementary feeding practices that contribute to infant undernutrition include feeding foods of low nutrient density, low feeding frequency and not feeding nutrient rich animal foods. [3]

The WHO/UNICEF global strategy for Infant and Young Child feeding promoted the use of locally available foods as one important strategy to ensure optimal complimentary feeding. [4] However, in food insecure regions rich sources of micronutrients may not be available or affordable and the staple food contain high concentrations of phytates and polyphenols which negatively affect nutrient bioavailability. [5] Industry processed fortified and micronutrient supplements specifically designed for 6-24month old children can be an important strategy to cover the nutrient gaps. Small quantity lipid based nutrient supplements (SQLNS) have been shown to be effective in improving nutrient intake without displacing family foods. [6], [7] SQLNS are energy and nutrient dense pastes that are designed to provide about 100 kcal and approximate daily requirements of multiple micronutrients and essential fatty acids in a 20 g serving to be fed daily. [8]

In Zimbabwe, the prevalence of stunting among under 5 children in the country is high at about 27%.[9] Children's diets are very poor; according to the most recent demographic

health survey[9] only 12% of children 6–24 months are fed a minimally adequate diet. The survey also showed that fewer than 30% of children in this age group were fed foods from at least four of the seven key food groups the day before the survey. [9] An in-depth study identified 10 major complementary feeding problems in rural Zimbabwe.[10] These included feeding a limited variety and low density energy foods, low feeding frequency, low amount of food served at each meal, reduced breastfeeding frequency and not assisting the child when eating. The most common problem was feeding a very limited variety of foods because mothers believed infants could not chew and swallow fruits, vegetables, and meats. [10] The most impactful messages developed from this work directly addressed these cultural barriers. These were “an infant can eat any food adult eats” “grind food so infants can swallow and digest it,” and “food that is locally available is important for your baby.” With this counselling, mothers of 6-12 month infants were able to feed their children diets that were adequate in all nutrients except iron and zinc. [10], [11]

Based on this formative study, we designed a complementary feeding (CF) intervention which was implemented as part of the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) trial. [12], [13] In intervention or CF arms, participants were provided with 20 g SQLN per day from 6-18 months and infant feeding behaviour change communication (BCC) during home visits by village health workers (VHWs). [11] In the non-CF groups, participants did not receive any intervention messages or inputs. Uptake of the intervention was assessed using the World Health Organization (WHO) Infant and Young Child Feeding (IYCF) indicators when infants were 12 months of age. We have previously reported that compared with infants in the non-CF groups, a higher proportion of those in the CF groups had reportedly consumed diets that met minimum dietary diversity (70% vs

53%) and had consumed animal-source (70% vs 62%), iron-rich (96% vs 49%), and vitamin-A-rich (79% vs 69%) foods in the previous 24 hours, suggesting the complementary feeding counselling had been impactful. [13] Moreover, 93% of children in the IYCF groups had consumed the small-quantity lipid-based nutrient supplement in the previous 24 h, indicating high uptake of this supplement. [13]

This study was done to investigate adequacy of nutrient intake and food-group consumption in a subset of children enrolled into the SHINE study by intervention arm. The specific objectives of this study were to (1) assess whether the CF intervention improved intake of energy and key macro and micro nutrients (2) examine the contribution of SQLNS and BCC separately and (3) examine whether the intervention improved the prevalence of adequate diet.

Methods

Study design and participants

This study was a sub-study within the SHINE trial, a 2x2 cluster randomized trial testing the independent and combined effects of improved complementary feeding (CF) and improved household sanitation/hygiene (WASH) on length-for-age Z score and hemoglobin concentration of children at 18months of age. The SHINE trial has been previously described [12] and primary outcomes reported. [13] The trial was conducted in two rural districts in central Zimbabwe, Shurugwi and Chirumhanzu where most households in these districts subsist through small-scale farming, and poultry and cattle keeping. A total of 5280 women were enrolled at a median gestational age of 12.4 weeks. A total of 212 clusters (defined as the catchment area of 1-4 village health workers (VHWs)) were randomized to one of 4 treatment arms: a standard of care (SOC) or control arm, a

complementary feeding (CF) arm, a WASH arm, or a combined arm with both WASH and CF interventions. This was a 2x2 factorial design

All enrolled women were scheduled to receive 15 arm-specific behavior change communication (BCC) home visits by their VHW between enrollment and 12 months post-partum (~1/month). [12] The content of the BCC was specific to each intervention arm. In the SOC arm all these visits covered standard messages of the Ministry of Health and Child Care (MOHCC) while in the WASH and CF arms the visits included standard of care and additional specific messages. [11], [14], [15] The hypotheses of the present analysis pertain only to the CF intervention. Briefly, in the CF arms participants were provided with (SQLNS) starting at 6 months. The nutrient content of the SQLNS provided in this study is shown in table 2.1. They also received BCC messages relevant to the developmental stage of their child and discussed how to safely and adequately introduce complementary food after 6 months, feeding during illness and how to feed a diverse diet.

All the messages were delivered by VHWs supervised by research staff within the SHINE trial. Lessons included messages and interactive tools and activities, previous lessons were reviewed before introducing new information to create a sequenced integrated longitudinal intervention. After the infants were 12 months, VHWs continued monthly visits to deliver inputs and provide informal reminders. A more detailed description of the trial and interventions and visit schedule is described elsewhere. [12], [14], [15]

Table 2.1: Small Quantity Lipid based Nutrient Supplement (SQLNS) formulations in formulation (per 20g daily ration)

Nutrient	Formulation for SHINE Trial
Ration (g/day)	20
Total energy (kcal)	118
Protein (g)	2.6
Fat (g)	9.6
Linoleic acid (g)	4.46
α -Linoleic acid (g)	0.58
Vitamin A (μ g RE)	400
Vitamin C (mg)	30
Vitamin B ₁ (mg)	0.3
Vitamin B ₂ (mg)	0.4
Niacin (mg)	4
Folic acid (μ g)	80
Pantothenic acid (mg)	1.8
Vitamin B ₆ (mg)	0.3
Vitamin B ₁₂ (μ g)	0.5
Vitamin D (IU)	200
Vitamin E (mg)	6
Vitamin K (μ g)	30
Iron (mg) ¹	6
Zinc (mg)	8
Cu (mg)	0.34
Calcium (mg)	280
Phosphorus (mg)	190
Potassium (mg)	200
Magnesium (mg)	40
Selenium (μ g)	20
Iodine (μ g)	90
Manganese (mg)	1.2

Sampling

For this sub-study, households were eligible to participate if they were still actively enrolled in the SHINE trial and had a child less than 12 months of age on January 1 2016. A total of 200 households (50 from each study arm) were randomly selected for this sub-sample. This sample size was based on financial and logistical considerations. We used data from our formative work to estimate nutrient intake in the non-CF arms and standard deviations for all nutrients and conducted a post hoc power calculations. Our sample size

was sufficient to detect a true difference in the mean energy intake of 41Kcal (10% relative increase in intake) in the CF compared to non-CF subjects with probability (power) 0.8, $\alpha=0.05$, 0.75 g (8% relative increase in intake) for protein, 1.1 g (11% relative increase in intake) for fat, 23 μg (27% relative increase in intake) for vitamin A, of 4.1 μg (14% relative increase in intake) for folate, 5.7 mg (10% relative increase in intake) for calcium, 0.22 mg (10% relative increase in intake) for iron and 0.19 mg (8% relative increase in intake) for zinc. All sample size calculations were done using the power and sample size program of Stata version 14.1.

Socio demographic characteristics and anthropometric data

All enrolled women were interviewed by research nurses at beginning of the SHINE study, about two weeks after providing consent to collect maternal and household characteristics. Data collected included maternal education, marital status, religion, age and occupation, number of household members, children less than five, infant gender and socio-economic status (SES). Infant weight was collected at the time of visit for this current sub-study and measured to the nearest 0.01kg using an electronic Tanita BD-590 (Arlington Heights, IL, USA) scale. Infant age was also recorded at the time of visit. All the research assistants were standardized for anthropometric measurements every 6 months for the duration of the SHINE trial.

Dietary assessment

Dietary assessments were conducted by trained research assistants to determine everything a child was fed the previous day. The research assistants were trained over a 5-day period; one day in a classroom setting, followed by 4 days of field training to standardize

procedures. Further in-field spot checks and shadowing were conducted to ensure that researchers were not drifting from the protocol. Data were captured in the local language using a netbook, however paper forms were available in case of technology problems.

All 24-hour diet assessment visits were conducted between January and September 2016. Recruited households were visited for an initial diet recall and 13% of the sample was randomly selected to be visited for a second visit between 1-2 weeks from the first visit. These repeated assessments were used to calculate dietary adequacy as described below.

Dietary assessments were conducted using a multi-pass 24-hour recall method to determine everything a child consumed during the previous day; the method had been previously used in Zimbabwe.[10], [11] The dietary recall assessed all food and beverages consumed in the previous 24 hours aside from breastmilk, which was not estimated. Diet recall interviews were conducted with the caregiver who fed or observed the infant consuming the recalled food or drink. The multi-pass method consisted of 5 passes. In the first pass, the caregiver was asked to freely list all the foods fed or consumed by the child during the previous day from the time they woke up to the time they went to bed. They were also asked to list any night feeds other than breastmilk. In the second pass, the caregiver was asked to list all their activities in the previous day; as each activity was reported the caregiver was asked if they fed the child food during or between each of the activities. This was done as a way to help the caregiver remember all the feeding episodes. In the third pass, for each food and beverage named during the free list, the caregiver was asked to give the time and place of preparation, all ingredients that were added and details of the brand for commercially produced foods. In the fourth pass, the caregiver estimated the portion size consumed by

the child. Research assistants carried samples of several common foods. Caregivers were asked to demonstrate the amount the child consumed using their household spoon, cup or plate actually used to feed the child. The research assistant then transferred the estimated portion to a standard cup, spoon or digital scale for recording. For mixed recipes the caregiver was asked to specify each ingredient that the child consumed. In the final (fifth) pass the caregiver was asked to recall if there were any missing foods from the list.

Data preparation and statistical analysis

All data were checked by trained personnel and were entered into Nutrisurvey software (<http://www.nutrisurvey.de>) to convert the amount of foods consumed into nutrient intake data. We used a combination of food composition tables including the Zimbabwe food composition data[16] , FAO/INFOODS food composition database and some regional food composition tables from southern African countries. [17]–[19]

Background characteristics were compared between non-CF and CF arms. The primary outcome was the difference in the estimated intake of specified nutrients from complementary food by children in the non-CF compared to CF arms. All analysis was by intention to treat according to the randomized intervention arm. The distributions of dietary intake variables were created and visually examined for normality, non-normal data were square root transformed. Analysis of square-root transformed data were first completed with the use of unadjusted ANOVA and overall significance determined using an F statistic. For the adjusted models, covariates were offered if their association with the outcome had significance at $p < 0.2$ in a bivariate analysis. Randomized intervention group (CF vs non-CF) was used as the exposure variables and the mean nutrient intake used as

the outcome variable. In final analysis robust confidence estimates were used in place of the transformed variables to provide a meaningful β coefficient and 95% CI. Models contained a dummy variable representing the main effect of the CF intervention (the two CF groups compared with the two non-CF groups). Although the study was not powered to detect a statistical interaction between the two interventions, we estimated these interactions for each outcome. None of the interactions were significant, hence the two main effects were collapsed into CF (CF and WASH+ CF) and non-CF (WASH and SOC).

We also compared the probability of meeting dietary adequacy for children in CF and non-CF arms. To assess diet adequacy, energy and nutrient intakes were compared with the estimated requirement using the WHO estimated energy requirement, the US Department of Agriculture–recommended daily allowance for protein, and the WHO-recommended nutrient intakes (RNIs) for vitamins and minerals.[20]–[22] Required nutrient intake from complementary foods were calculated by subtracting the amount of energy/nutrient in an average intake of breast milk (500 g for 12–24 months) from the total requirement.[23] Energy requirement was calculated as kilojoules required per kilogram of body weight using standardized bodyweight for children 12-24months. The requirement for fat was estimated as 30% of the energy requirement.[23] Because of the large discrepancy between the US dietary reference and the WHO RNIs, we estimated the requirement of calcium from complementary food using a recommendation between the two. For zinc and iron, 30% and 10% bioavailability, respectively, were assumed. [23] We analyzed for prevalence of adequate intake from complementary food in intervention compared to control arms.

To calculate the prevalence of adequate diet for each nutrient we used the nutrient intake data variables and we used box cox power transformations to approximate normal intake distributions. We then calculated individual and population means for the intakes of each nutrient, as well as within- and between-person variances for the transformed variables based on data from the subsample of children with two days of intake data. Next, we calculated the best linear unbiased predictors (BLUP) of the usual intake for each child and from those predictors, the probability of adequacy (PA) for each nutrient was calculated using the probability method [24]–[26]. PA was defined as the probability that a respondent’s usual intake met the WHO/FAO nutrient requirement distributions. When averaged across all children, the PA is equivalent to a population-level estimate of prevalence. [24]–[26] Where it was not available the estimated average requirements (EAR) was back-calculated from RNI and the standard deviations were calculated from the coefficient of variation (CV). The mean probability of adequacy (MPA) was calculated as the mean of the PAs for all nine nutrients. [26], [27]

We also analyzed the different food groups consumed using the grams of food eaten. A food group was first counted as eaten if at least 1g was consumed. We also counted the food groups a second time, where a food group was counted as consumed if 15g was consumed

Ethical approval to conduct this study was granted by the Medical Research Council of Zimbabwe and the Institutional Review Boards of Johns Hopkins University Bloomberg School of Public Health and the Research Institute of McGill University Health Centers. The SHINE trial is registered at ClinicalTrials.gov Identifier: NCT01883193.

Results

Among the 1286 infants who were eligible for this study at enrollment, 200 caregiver-infant pairs were randomly selected, and 195 of those were enrolled for this sub study (figure 2.1). A total of 218 recalls were collected, an initial recall was collected from all 195 enrolled children and a second recall 2 weeks later from 25 (13%) randomly selected children.

The infant, caregiver and household characteristics were similar in the CF vs non-CF arms (table 2.2). About 50% of the children were male and the birth weight was about 3 kg. At 12 months the infant weight was about 8.83kg across the arms. Most caregivers had attended high school, were Christian and married. Households were an average size of about 5 people including the index child. Households were equally distributed in each of the 4 quartiles of the SES index with slightly higher proportions in the upper middle quartile (28% in non-CF and 32% in CF arms)

Energy intake was mean (SD) 543.(399) among children in the CF group and 430(268) among those in the non-CF arms (β 113.07 (95% CI) (17.12,209.03) $p=0.021$); this difference was stronger in the adjusted model (123.41(15.98,230.85) $p =0.025$) Mean protein intake was 2.48 g (-0.33,5.28) higher among children in the CF compared to non-CF group although this difference was not significant $p=0.083$. Fat intake was significantly higher in the CF group in both unadjusted (β 7.48 (95% CI) 3.16,11.81) $p =0.001$) and adjusted (β 7.57 (95% CI) 2.53,12.62) $p =0.003$. Finally, children in the CF group consumed significantly higher intakes of all micronutrients. (table 2.3)

Figure 2.1: Participant flow chart

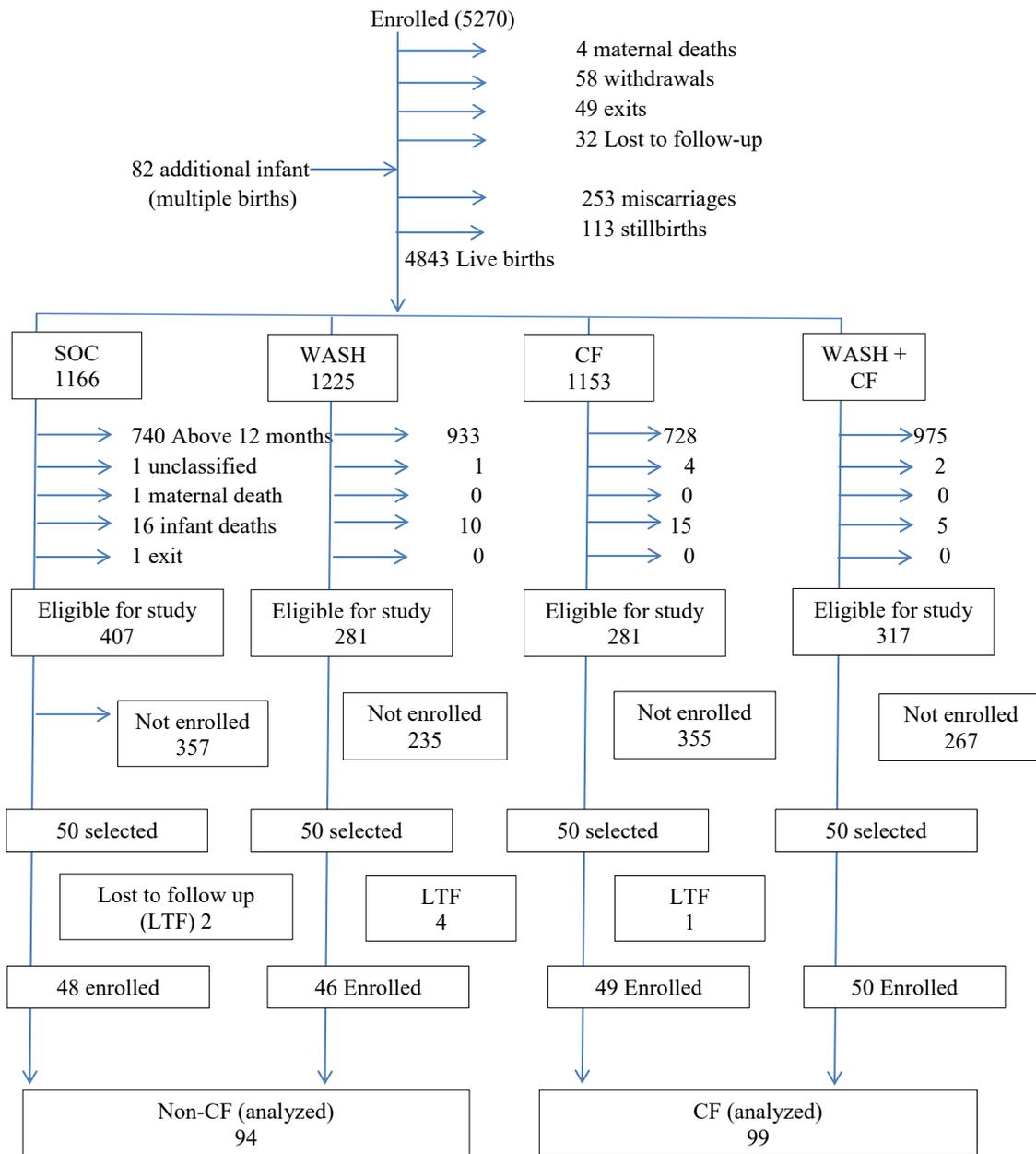


Table 2.2: Caregiver and household characteristics

Characteristics	Non-CF (n=94) mean (SD)/ %	CF (n=99) mean (SD) %
<i>Infant characteristics</i>		
Age (months)	12.54 (1.57)	12.49(1.29)
Male (% yes)	50	55
Birth weight (kg)	3.1(0.42)	3.05(0.5)
Weight at 12 months (kg)	8.75(1.29)	8.91(0.93)
<i>Caregiver characteristics</i>		
Age (years)	28.06(6.55)	27.66(6.24)
Some high school (% yes)	76	83
Married (% yes)	99	98
Christian (% yes)	92	90
<i>Household characteristics</i>		
Household size (persons)	4.38(1.51)	4.62(2.28)
SES Index: lower (%)	24	22
SES Index: lower middle (%)	23	21
SES Index: upper middle (%)	28	32
SES Index upper (%)	24	24

Table 2.3: Energy and nutrient intake of SHINE infants by CF group, SQLNS included (n=195)

Nutrient	CF Mean (SD) n=100	Non-CF Mean (SD) n=95	Unadjusted β (95% CI)	P>t	Adjusted* β (95% CI)	P>t
Energy (kcal)	543.4(398.5)	430.3(267.7)	113.07(17.12,209.03)	0.021	123.41(15.98,230.85)	0.025
Protein (g)	13.8(9.8)	11.9(8.6)	1.98(-0.64,4.60)	0.137	2.48(-0.33,5.28)	0.083
Fat (g)	17.8(19.5)	10.3(9.4)	7.48(3.16,11.81)	0.001	7.57(2.53,12.62)	0.003
Vitamin A	550.2(308.3)	286.6(1200.7)	263.55(11.77,515.33)	0.040	382.31(296.34,468.30)	0.000
Folate (μ g)	111.4(82.7)	36.8(45.5)	74.63(55.80,93.46)	0.000	80.95(61.46,100.44)	0.000
Calcium (mg)	342.5(172.5)	108.7(128.1)	233.85(190.85,276.86)	0.000	239.12(202.90,276.35)	0.000
Iron (mg)	12.6(34.2)	3.7(3.7)	8.88(2.06,15.7)	0.011	8.25(1.85,14.66)	0.012
Zinc (mg)	9.3(4.7)	2.5(1.5)	6.85(5.87,7.84)	0.000	6.88(5.92,7.86)	0.000

CI = confidence interval SD= standard
*Adjusted for maternal education, household size, SES, infant age, infant weight at12months, infant gender

To assess the contribution of BCC without SQLNS, the nutrient contribution of SQLNS was mathematically calculated and excluded from the analyses. When the SQLNS was excluded from the analysis intake from food only was not different between the children in the CF compared to non-CF groups for any nutrient (table 2.4)

The estimates of prevalence of adequate intake were significantly higher in CF groups compared to non-CF groups for all nutrients. In the non-CF arms prevalence ranged from very low (1-11%) for calcium, folate and vitamin A; to low (40-50%) for energy and iron; to moderate (64-65%) for fat and zinc and high (82%) for protein. In CF arms it ranged from low (26-29%) for folate and calcium; to moderate (59%) for energy to high (82-92%) for vitamin A, zinc, iron and protein. (Figure 2.2)

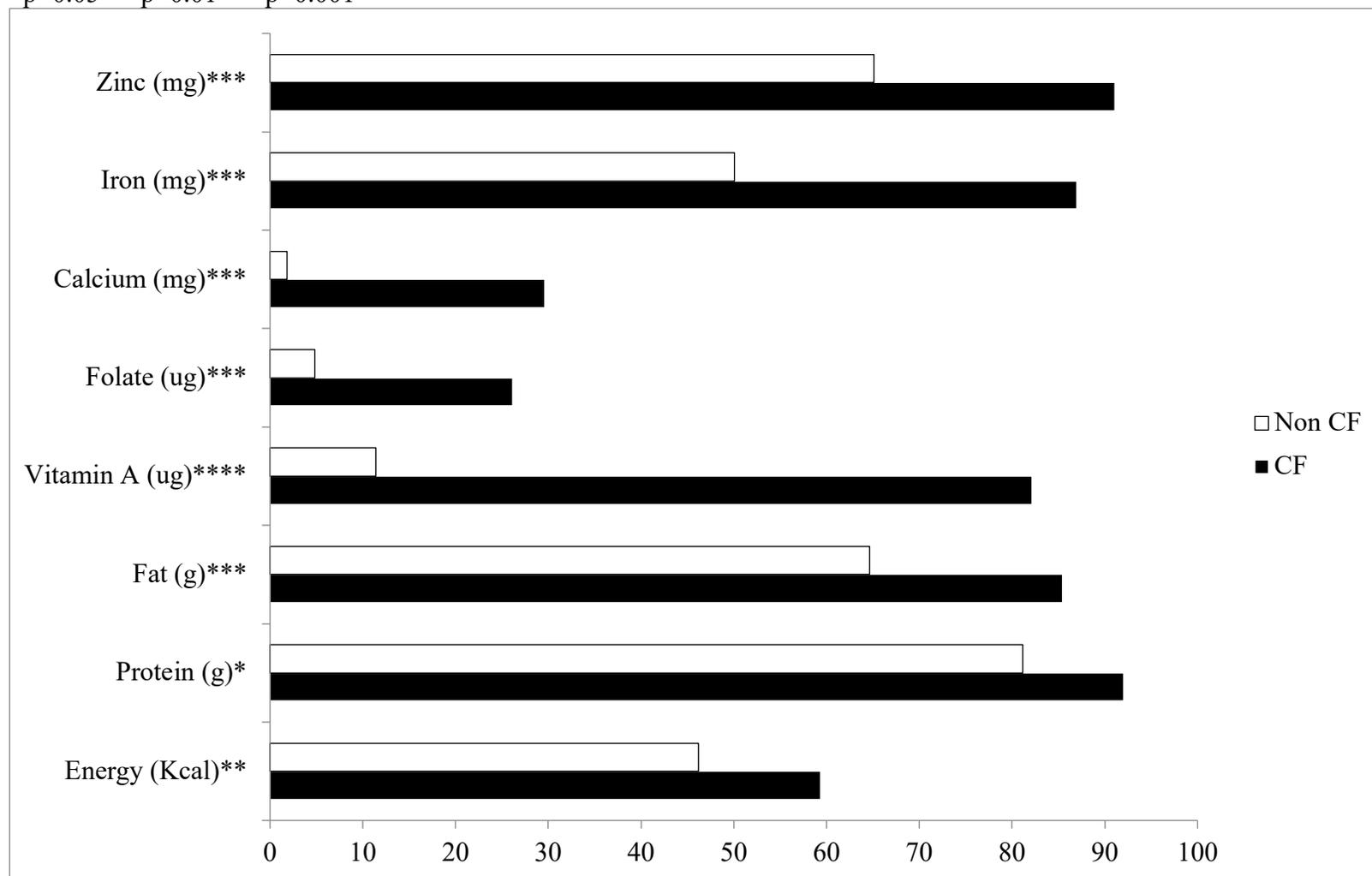
Table 2.4: Energy and nutrient intakes of SHINE infants by CF group, SQLNS excluded

Nutrient	CF Mean (SD)	Non-CF Mean (SD)	Unadjusted β (95% CI)	P>t	Adjusted* β (95% CI)	P>t
Energy (kcal)	443.9(390.2)	430.3(267.7)	13.55(-81.06,108.16)	0.778	25.14(-0.81,42)	0.642
Protein (g)	11.6(9.7)	11.9(8.6)	-0.21(-2.83,2.40)	0.874	0.31(-0.25,3.12)	0.828
Fat (g)	9.7(18.9)	10.3(9.4)	-0.61(-4.82,3.60)	0.775	-0.42(-5.40,4.57)	0.869
Vitamin A (μg)	212.8(237.8)	286.6(1200.7)	-73.822(-322.58,174.93)	0.559	49.18(-29.97,128.33)	0.222
Folate (μg)	44.0(68.4)	36.8(45.5)	7.16(-9.27,23.59)	0.391	14.33(-2.99,31.64)	0.104
Calcium (mg)	106.4(87.6)	108.7(128.1)	-2.31(-33.62,29.01)	0.885	6.43(-19.20,32.05)	0.621
Iron (mg)	7.6(33.8)	6.2(16.4)	1.32(-6.17,8.82)	0.728	1.08(-5.83,7.99)	0.757
Zinc (mg)	2.6(1.8)	2.5(1.5)	0.11(-0.37,0.59)	0.660	0.23.13(-0.28,0.73)	0.379

CI = confidence interval SD= standard deviation
*Adjusted for maternal education, household size, SES, infant age, infant weight @12months, infant gender

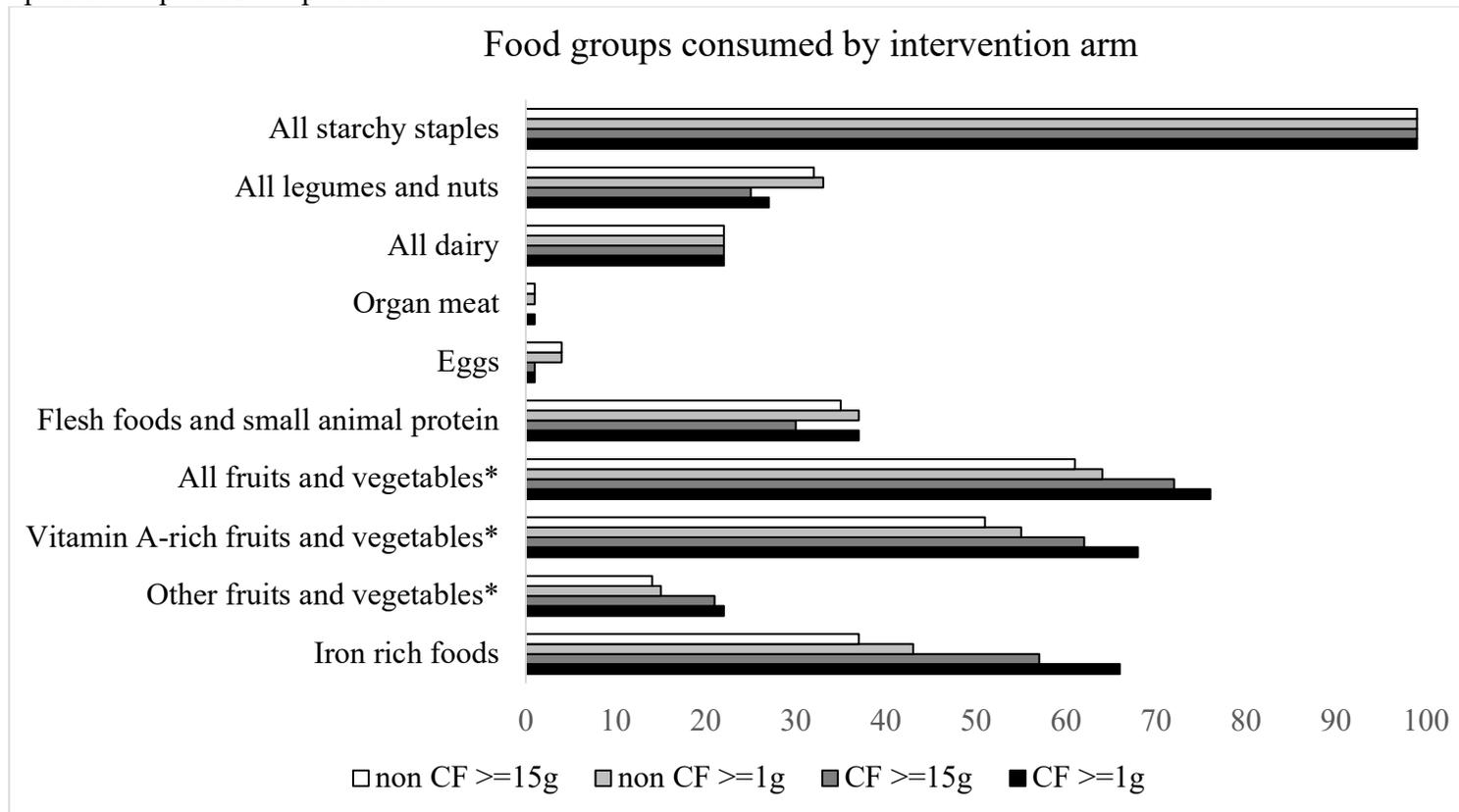
Figure 2.2: Estimated prevalence of adequate intake of specified nutrients by intervention group

*p<0.05 ** p<0.01 ***p<0.001



Dietary patterns at 12 months are detailed in figure 2.3, which shows the proportion of children in the CF and non-CF arm who consumed each of 9 food groups. The patterns for children in the CF group were similar to the non-CF groups for all food groups except fruits and vegetables. All children were reported to have consumed starchy staples, about one in three consumed legumes/nuts and about 1 in 5 had dairy in both CF and non-CF groups. Consumption of eggs and organ meat was almost nonexistent; however, about a third consumed other fleshy foods or small animal protein. Consumption of vitamin A rich dark leafy vegetables was higher in the CF groups (30%) compared to the non-CF group (19%) ($p < 0.05$). Consumption of “other” (non-vitamin A rich foods) was also higher in CF groups (21%) compared to non-CF group (14%) ($p < 0.05$). For all food groups there were no substantial differences between the 1 g and the 15 g cutoffs; that is, those who had 1g of these foods also tended to have at least 15 g.

Figure 2.3: Proportion of children consuming different food groups using two limits to define consumption
 *p<0.05 ** p<0.01 ***p<0.00



Discussion

In this randomized intervention study, which was delivered through home-based visits, infants whose mothers received BCC and SQLNS had significantly higher intakes of all nutrients from non-breastmilk foods (complementary foods + SQLNS), except for protein. However, the intervention effect was attributable to the SQLNS for all nutrients. This suggests that there was BCC alone without the provision of a supplement may not improve nutrient intake. Nutrient intakes from foods other than SQLNS were similar across the trial arms, which suggests that there was minimal or no displacement of other complementary foods from SQLNS. This may suggest that the BCC may have been important in ensuring that children continued to consume other foods in addition to the SQLNS. This finding is consistent with two studies in Malawi infants [18], [19] and one study in Ghana [28] that showed an improvement in energy intake with provision of SQLNS and no displacement of complementary foods. These studies were testing the impact of (1) different doses of lipid nutrient supplements (LNS) [6], [28] or (2) SQLNS compared to another type of supplement [19] on nutrient intake. None of these comparison studies included BCC, hence we cannot say if intake from complementary foods would have improved with BCC in these settings. Our earlier formative work showed an improvement in nutrient intake with and without SQLNS supplementation. [29], [30] However, these studies [29], [30] (1) had no comparison group, (2) had small sample sizes and (3) the frequency of BCC messages was much higher, weekly compared to monthly in this study.

The mean intake of all macro- and micro-nutrients were well above the requirement from complementary foods in the CF group while in the non-CF group only protein, fat and vitamin A were above the requirement. Energy, folate, calcium, iron and zinc were well

below the requirement in the non-CF group. The prevalence of adequate intake was also lowest for these micronutrients. This is consistent with our earlier work in rural Zimbabwe that showed very low consumption of the micronutrients folate, calcium, iron and zinc at baseline with significant improvements after provision of SQLNS. [29], [30]. However as mentioned above these studies had very small sample sizes and no comparison group. The infants were also younger (9 months) compared to the average age of 12 months in this study which limits the comparisons that can be made.

The results of the SHINE trial showed that CF improved length-for-age Z score by 0.16 (95% CI 0.08–0.23) and the mean hemoglobin concentration by 2.03 g/L (1.28–2.79) in the intervention compared to the non- intervention groups. [13] The intervention also reduced the number of stunted children from 620 (35%) of 1792 to 514 (27%) of 1879, and the number of children with anemia from 245 (13.9%) of 1759 to 193 (10.5%) of 1845.[13] The results of this in-depth assessment of infant diets show that the CF feeding intervention improved infant nutrient intake and the prevalence of adequate diets. Additionally, this study showed that provision of SQLNS in addition to the BCC was important for the observed intervention effects in this study.

Strengths and limitations

Our study has several strengths, first we used a randomized design to allocate interventions hence providing an objective measure on the impact of the intervention on infant diets in rural Zimbabwe. We also paid close attention to measurement error by using household measures as well as food samples to improve estimation of portion size. Data collectors went through rigorous training and standardization as well as daily debriefing sessions to

ensure consistent and accurate results. In addition, a random proportion of all visits were shadowed and issues with portion size estimation discussed and shared with all data collectors for standardization.

Our results should however be interpreted in the context of several limitations. The sample size for this study was based on logistical considerations and not sample-size calculation. A post-hoc power calculation showed that we had adequate power to detect differences for most of our outcomes. This study was also not blinded; therefore, we cannot rule out that caregiver or researcher bias may have led to biased estimation of intake. We minimized researcher bias by having rigorous trainings for data collectors, spot checks and shadowing of visits. We also ensured that the data collectors were different from the people who delivered interventions to minimize caregiver bias.

There is also potential measurement error from different sources in the 24-hour recall. We used the same measurement method throughout, which means similar measurement error will exist among the intervention and non-intervention groups, except possibly for the estimation of SQLNS intakes. A systematic error in SQLNS intake estimations would not affect the estimates of non-SQLNS CFs; thus, it would not alter our conclusion that SQLNS did not displace other complementary foods in the CF group. However, if SQLNS intake was overestimated, this would have inflated the estimates of total macro and micronutrient intake in the CF group but not in the non-CF group.

Conclusion

We found that a CF intervention that included BCC and SQLNS supplementation was effective in increasing nutrient intake and the prevalence of adequate diet in the intervention group. We also noted that provision of SQLNS in addition to the BCC was particularly important for the observed impacts. BCC alone did not have an impact on nutrient intakes in the intervention group. This result may help explain why BCC without provision of a supplement may not have an impact on growth in food insecure contexts. We also found no significant differences in micro- and macro-nutrient intakes from non-SQLNS foods between CF and non-CF groups suggesting that provision of SQLNS in a 20g dose with associated BCC did not result in displacement of complementary foods.

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CHAPTER 3

ASSESSING THE IMPACT OF A COMPREHENSIVE PACKAGE OF WATER SANITATION HYGIENE (WASH) INTERVENTIONS TO REDUCE INFANT FECAL EXPOSURE TO FECAL MICROBES IN RURAL ZIMBABWE

Abstract

Background: Children living in conditions of poor hygiene and sanitation are frequently at risk of infectious diseases and more likely to be stunted. Mouthing behaviors through exploratory play have been identified as the primary pathway for fecal-oral microbial transmission in children under 24 months. Available interventions however do not address this pathway focusing instead on household- and community-level hygiene behaviors. A comprehensive package of interventions that targeted these behaviors was implemented as part of the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) Trial, a cluster-randomized study of the independent and combined effects of complementary feeding and water and sanitation/hygiene (WASH) interventions in rural Zimbabwe. **Objective:** We aimed to determine whether there were empirically observable differences in ingestion of soil, feces and other visibly dirty objects among children enrolled in the intervention compared to non-intervention households. **Methods:** We recruited a sub-sample of 180 caregiver-infant pairs and conducted in-depth 6-hour observations to record all hand-to-object, object-to-mouth, and child hand-washing events during the observation period. All mouthed objects were classified into 13 categories and total frequency of all mouthing and the frequency of mouthing or ingesting each category of objects when they were visibly

dirty was calculated. Logistic regression was used to assess the difference in proportion between WASH and non-WASH groups for binary outcomes. Zero truncated negative binomial regression models were used for assessing the difference in frequency of mouthing events between the WASH and non-WASH groups for objects in each of the 13 categories of objects among the children who had at least one event. **Results:** The intervention was associated with a lower odds of ingesting four categories of objects at least once during the 6-hour observation: soil by 55% (odds ratio (OR) 0.45 95%CI [0.25,0.85]); visibly dirty cups or spoons by 41% (OR 0.59 (0.32,0.88), beverages by 64% (OR 0.36 (0.18,0.68), and shoes by 60% (OR 0.40 (0.17,0.91). The WASH intervention had no effect on frequency of mouthing all categories of objects except visibly dirty food, where frequency was lower in WASH arms (IRR 0.61 (0.41,0.91). The intervention had no effect on infant hand washing. **Conclusion:** The package of WASH interventions reduced but did not eliminate exposure to vectors of fecal-oral microbial transmission in children. The interventions represent a promising strategy however further research is needed to understand more effective intervention strategies.

Introduction

Young children engage in normal exploratory behaviors that can include mouthing as part of the normal developmental process. Mouthing can be nutritive and nonnutritive, with the former mostly occurring in the context of feeding, and the later mostly as part of exploratory play and includes hand-to-mouth and object-to-mouth ingestion.[1] In either of these, mouthing can become a pathway for ingestion of environmental contaminants when their living environment is contaminated with pesticides,[2], [3] heavy metals,[4]–[6] or enteric pathogens,[7]–[12].

Baby observation studies in Zimbabwe,[13] Peru,[14] and Bangladesh,[15]–[17] have shown that babies ingest animal feces and soil through exploratory mouthing, and that soil in these environments has high counts of *Escherichia coli*. [13], [15] Soil ingestion (geophagia) has been linked to intestinal helminth infections,[7], [11] growth faltering,[15], [16] and diarrhea.[12], [18], [19] For example, studies in peri-urban Peru [14] and rural Kenya[12] used caregiver-reports to estimate child ingestion of feces and soil, and found that the frequency of ingesting the fomites was significantly associated with incident diarrhea among young children. Geophagia has also been associated with fecal indicators of environmental enteric dysfunction (EED).[15], [16] EED is a subclinical disorder of the gut, hypothesized to result from chronic fecal pathogen exposure, which may in turn contribute to growth faltering through its characteristic gut and systemic inflammation and impaired nutrient absorption.[20], [21]

Water and sanitation/hygiene (WASH) interventions have been implemented widely to minimize fecal-oral contamination. [22] However, conventional WASH interventions focus on hand washing with soap at key times, access to improved water, point-of-use drinking water treatment and improved sanitation. Recognition that hand/object mouthing and non-nutritive ingestion may be primary pathways for fecal-oral microbial transmission among the very subpopulation at highest risk of diarrhea and stunting (under-2-year old children) and that these behaviors are not interrupted by conventional WASH interventions led our group to propose the concept of “Baby WASH”. [13], [22][23] Baby WASH interventions differ from conventional WASH in that instead of adult behaviours they target the faecal-oral pathways introduced by prevalent mouthing and exploratory play unique to young children. Given the propensity to ingest anything in their environment, we also focused our attention on both human and animal faeces.

We implemented Baby WASH interventions as part of a broader household WASH intervention within the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) trial. In intervention arms both baby WASH and conventional interventions were implemented while the non-WASH group did not receive any WASH intervention. We previously reported that the baby WASH intervention showed promising results based on maternal reports. Significantly fewer mothers randomized to the WASH compared to non-WASH arms reported ever seeing their child ingest soil (27% versus 73%) and chicken feces (3% versus 21%) at 12 months of age. [24]

The aim of the current study was to objectively determine whether there were empirically observable differences in ingestion of soil, feces and other visibly dirty objects. We

conducted an observation study, with structured observation methods to assess these behaviors in a subset of infants (90 WASH, 90 Non-WASH). We hypothesized that a smaller proportion of children in the WASH arms would ingest soil, animal feces, visibly dirty food and beverages, and other visibly dirty objects.

Methods

Study design

This study was a sub- study within the SHINE trial which enrolled 5280 pregnant women between November 2012 and March 2015 and followed their children until 18 months of age; the last child turned 18 months in July 2017. The design and methods of the SHINE trial have been previously reported. [25] Briefly, SHINE was a 2x2 cluster randomized factorial trial to test the independent and combined effects of improved household WASH and improved infant feeding on child linear growth and hemoglobin at 18 months of age. SHINE was conducted in Shurugwi and Chirumanzu, two rural districts in central Zimbabwe. Most families in the study area subsist through small-scale farming, and poultry and cattle keeping. Households generally consist of one to four separate buildings for cooking, sleeping, and other activities and are constructed of traditional mud or brick. The area between the buildings is open yard with bare, loose sandy soil and no fence; we refer to this as the ‘kitchen yard’ in this paper.

A total of 212 clusters (defined as the catchment area of 1-4 village health workers (VHWs) were randomized to one of 4 treatment arms: standard of care (SOC), complementary feeding (CF), WASH, or WASH and CF combined. All enrolled women were scheduled to receive 15 arm-specific behavior-change communication (BCC) home visits by their VHW between enrollment and 12 months post-partum (~1/month); lessons included

messages and interactive tools and activities. Previous lessons were reviewed before introducing new information to create a sequenced integrated longitudinal intervention. After 12 months, VHWs continued monthly visits to deliver inputs and provide informal reminders. The messages and tools used in all four intervention groups are detailed elsewhere. [25], [26]

The WASH intervention included both conventional WASH and Baby WASH interventions. Conventional WASH interventions included provision of an improved pit latrine, two handwashing stations, and monthly supply of soap and chlorine solution supported by BCC promoting safe faecal disposal, handwashing with soap at key times, and point-of-use (POU) chlorination of drinking water. Baby WASH interventions included provision of a washable mat (2 months), play yard (6 months) and several BCC messages: wash baby's hands after nappy change, when visibly dirty and routinely 3-4 times per day; keep child from eating soil and chicken feces; put child in clean protected space for playing and eating where he/she cannot access soil and chicken feces; once baby is mobile use play yard; give your baby drinking water which has been chlorinated and food which has been freshly prepared or reheated to boiling.

Participants for the current sub-study were selected from a complete list of children who were still actively enrolled in the trial on November 1, 2016. Between November 2016 and March 2017, the 90 youngest babies in the two WASH arms were matched for gender and age with 90 babies in the two non-WASH arms. We selected the youngest children because mouthing behavior is more common in younger children.[27] The total sample size of 180 households (90 in the WASH and 90 in the non-WASH arms) was based on sample size

calculations to detect a 15% reduction in direct ingestion of soil in the intervention arms based on the 20% reduction estimated by maternal history. [24] Selected mothers were visited to obtain informed consent for this sub-study and consenting mothers were scheduled for the observation session on another day. Only one mother refused participation after signing the consent form. Four research nurses assessed all 180 children after a 5-day training period. The first day was an in-class training using videos for mock observations followed by 4 days of field training to standardize the observation procedures. Further in-field spot checks were conducted by field supervisors to ensure that researchers were not drifting from the observation protocol.

Data collection

Research nurses conducted a 6-hour observation and recorded all episodes of infant's mouthing or ingestion and cleanliness of the baby's environment. Pre-scheduled observation periods began between 7 am and 11 am and ended between 1 pm and 5 pm. Blinding of the mother and research nurse to study arm was not possible because of the nature of the intervention. At the beginning and again at the end of the observation, the research nurse observed and recorded the cleanliness of the mother's and infant's hands, whether the child's bottom or diaper were dirty, presence of stagnant water within reach of the child, general cleanliness of the kitchen and kitchen yard, number of corralled and roaming animals in the kitchen yard or household buildings, and presence of fecal material in the kitchen yard. Throughout the observation period, research nurses recorded the time the child spent sleeping.

Using a pre-tested structured questionnaire (Appendix 5), the research nurse recorded all hand-to-object, object-to-mouth, and child hand-washing events over the 6-hour observation period. Hand-to-object contact was defined as children touching any object in their environment. Object-to-mouth contact was defined as any object or food put into child's mouth by the child or caregiver during the observation period. For each object-mouth contact, the research nurse recorded the condition of the object as visibly dirty or not visibly dirty, and the number of times the object entered the child's mouth. Objects that were coated with soil (e.g. wet hands or fresh fruit) were recorded as soil mouthing events. Information was also collected on the caregiver's response to the child's mouthing event (for example, taking the object away from child or telling the child not to put object in their mouth).

To maintain the quality of data, each of the research nurses were shadowed for ~10% of their observations; debriefing sessions were held daily after every household visit. Researchers re-checked and crosschecked questionnaires and recording of key events and behaviors to maintain consistency in data collection. Post-coding of the questionnaires and manual double-data entry were conducted.

Data analysis

We first estimated an interaction between the WASH and CF interventions for each outcome because of the 2x2 factorial design of the primary trial, but none was significant, hence the two main effects were collapsed into WASH (WASH and WASH+ CF) and non-WASH (CF and SOC). Mouthed objects were classified into 13 categories: soil, infant hands, food, stones/sticks/grass, cups/utensils, clothes, beverages, fruit, index child body

parts other than hands, shoes, household items, toys, and other. The total frequency of all mouthing and the frequency of mouthing or ingesting each category of objects when they were visibly dirty was calculated. All soil-mouthing events were considered visibly dirty. We also analyzed observations for all instances when the mother actively stopped an object-mouth event.

Logistic regression was used to assess the difference in proportion between WASH and non-WASH groups for binary outcomes (*e.g.*, proportion of children ingesting soil). Binary variables were coded as 0 when the child had no object-to-mouth contacts and as 1 when the child had at least one object-to-mouth contact over the 6-hour observation period.

Zero truncated negative binomial regression models were used for assessing the difference in frequency of mouthing events between the WASH and non-WASH groups for objects in each of the 13 categories of objects among the children who had at least one event. The frequency of object-to-mouth contacts was defined as the count of event during the 6-hour observation period. For the adjusted models, covariates were added to the model if their association with the outcome had significance <0.2 in a bivariate analysis.

All data analysis was conducted using STATA 14.1

Daily exposure to fecal bacteria:

We estimated E coli ingestion in our WASH and non-WASH groups, based on the results of our previous study in the same area.[13] In that study it was estimated that the amount of dry soil a 12-month-old child could hold without spilling was 1.25g and the amount of soil that made 2-3 fingers visibly dirty is 0.25grams. We also estimated that the mean (95%

CI) concentration of *E. coli* in soil in kitchen yards in our study area was 69 (22-212) colony-forming units (CFU) per gram of soil. We used these values in the estimation calculations for total soil and *E. coli* ingestion.

Ethical approval.

Ethical approval to conduct this study was granted by the Medical Research Council of Zimbabwe and the Institutional Review Board of Johns Hopkins University Bloomberg School of Public Health. The SHINE trial is registered at ClinicalTrials.gov Identifier: NCT01883193.

Results

Maternal, infant and household characteristics

From 5280 pregnant women enrolled into the main trial, there were 4843 live births; 550 of these children were eligible for this sub study on Nov 1, 2016 (Figure 3.1). From these 550 children, 180 were selected and caregivers consented for the sub study, one withdrew prior to data collection. Hence structured observation data was collected for 179 children between November 2016 and March 2017.

At enrollment, infant and caregiver characteristics were similar except that fewer WASH households had dirt/dung floors and more had concrete floors compared to non-WASH households (table 3.1). On average; children were 18.8 ± 1.52 months and 54% (n=96) were male. Most caregivers had attended high school and were married. Households included an average of 3 children younger than 18 years. As expected, the inputs provided by the trial to the WASH arm (latrine, handwashing stations and soap) were higher in WASH compared to non-WASH arms

Figure 3.1: Participant flow chart

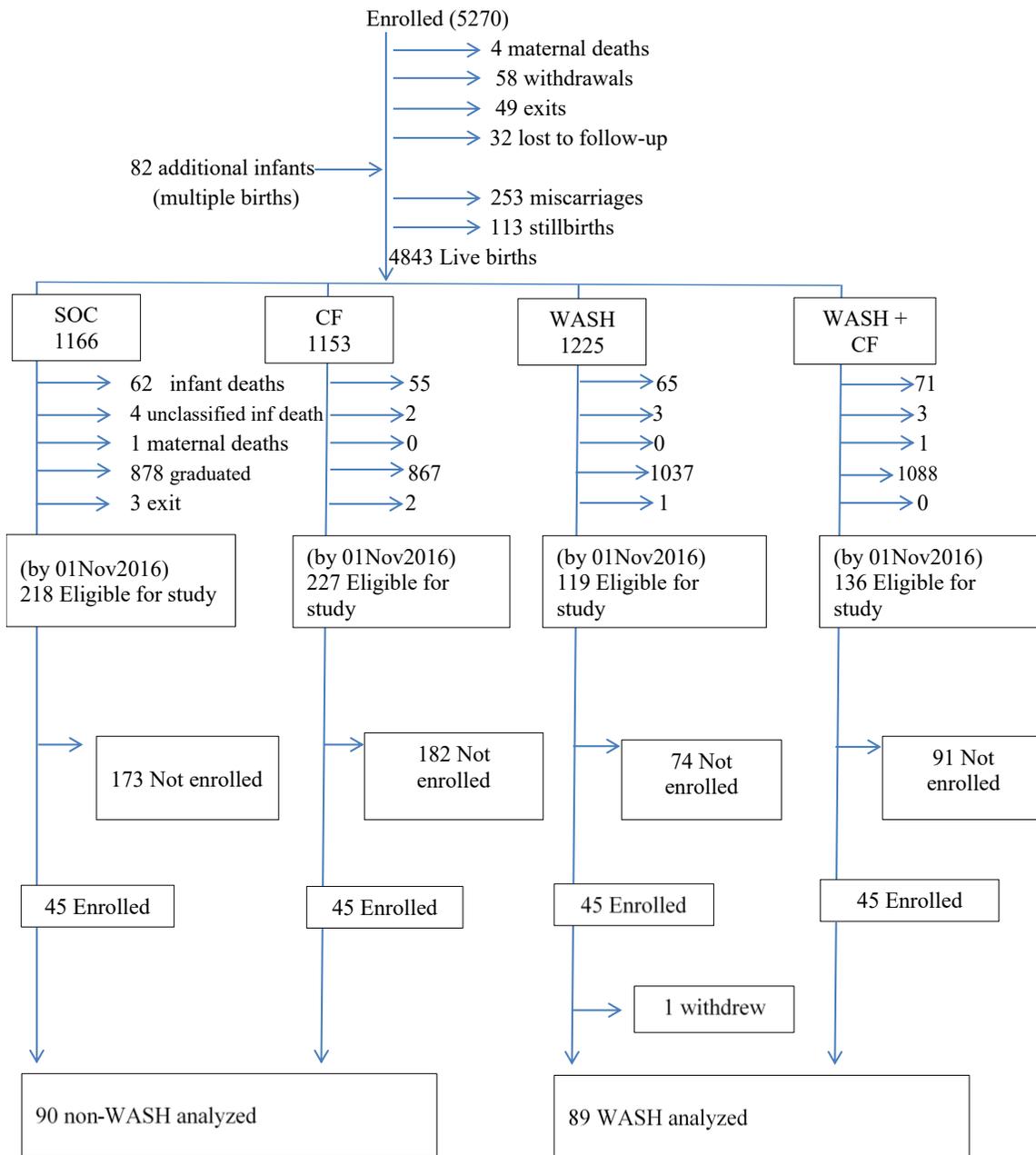


Table 3.1: Characteristics of study population[#]

	Treatment group	
	WASH (n=89)	Non-WASH (n=90)
Infant characteristics		
Age [mo, mean (SD)]	18.74(1.55)	18.76(1.51)
Gender		
Male	50(56.18)	44(48.89)
Caregiver characteristics		
Caretaker		
Mother	86(97.0)	88(98.0)
Other[‡]	3(3.0)	2(2.0)
Marital status		
Married	83 (93.2)	86 (95.6)
Divorced/widow/never married	6(6.8)	4(4.4)
Education level		
Primary	15(16.9)	13(14.4)
Secondary	72(80.9)	75(83.3)
Tertiary education	2(2.4)	1(1.1)
Missing data	0(0.0)	1(1.1)
No of children under 18 mean \pmSD	3.5(1.5)	2.8(1.5)

Household sanitation characteristics		
Type of floor		
Smooth concrete	54(61)**	39(43)**
Dirt/cow dung floor	38(43)*	50(56)*
Latrine		
Own	81 (91.0)	28(31.1)
Use neighbors	2 (2.3) †	4(4.4)
Does not use latrine	6(6.7) †	58(64.4)
Hand washing		
Hand-washing(H/W) station	75(84.2)	1(1.1)
Soap near H/W station	27(30.7)	0(0.0)
Water on the ground	12(13.5)	0(0.0)
Other evidence of use	20(22.5)	0(0.0)
Water storage container §		
	Completely covered	Completely covered
Drum	2(2.3)	6(6.7)
Jerry can	13(14.6)	14(15.6)
Bucket	65(73.0)	65(72.2)
Clay pot	1(1.2)	0(0.0)
<p>*p<0.10 **p<0.05 *** p<0.01 *****p<0.001 # Values are n (%) except where otherwise indicated. φGrandmother or stepmother §Households sometimes had more than one type of storage container. † Participants relocated from their original household where the trial latrine was built</p>		

General hygiene characteristics of infant's environment during observation

At the beginning and end of the observation period, about one-third of mothers and 40-60% of children had visibly dirty hands, which did not differ by group (table 3.2). The proportion of households with unwashed utensils was unexpectedly higher in the WASH arms compared to the non-WASH arms both at the beginning (75.2% compared to 58.9%) and end of the observation period (83.2% compared to 70.0%). The area where the child played was not swept in about a third of households in either intervention arm. Chicken feces were observed in about 70% of WASH households, (compared to over 75% in non-WASH households) and other animal feces were observed in about two-thirds of households in all arms.

Likelihood and frequency of vector-mouth contact

The objects observed as the mostly frequently mouthed were (in declining order of frequency) the index infant's hands, food, stones/sticks/grass, the infant's cup and spoon, soil, clothes, water and other beverages, the infant's own body other than his/her hands, household items and toys. (table 3.3). All children in both intervention arms mouthed a visibly dirty object at least once during the observation period.

The intervention was associated with a lower odds of ingesting four categories of objects at least once during the 6-hour observation: soil by 55% (odds ratio (OR) 0.45 95%CI [0.25,0.85]); visibly dirty cups or spoons by 41% (OR 0.59 (0.32,0.88), beverages by 64% (OR 0.36 (0.18,0.68), and shoes by 60% (OR 0.40 (0.17,0.91). In adjusted analysis the estimated values were slightly attenuated for soil but remained unchanged for the other objects and became stronger for cups and spoons. However, among children who ingested

these categories of objects at least once, the intervention had no impact on the frequency of mouthing or ingesting during the 6-hour observation period (table 3.3).

The WASH intervention had no effect on the proportion of children who mouthed visibly dirty food, however in those children who ever mouthed visibly dirty food the frequency was much lower in WASH children compared to non-WASH children (IRR 0.61 (0.41,0.91). This effect was stronger in adjusted models (table 3.3).

The intervention had no effect on both the proportion of children who ever mouthed and the frequency of mouthing visibly dirty fruits, body, toys, stone/stick/grass or other objects. The proportion of mothers who stopped children from mouthing or ingesting visibly dirty objects was similar in the WASH (38.2%) and non-WASH (34.8%) arms (table 3.4). The intervention had no effect on infant hand washing. This was true for total hand washing, hand washing with soap and hand washing at critical points (table 3.5).

Play yard use

Play yard use was observed in only 10% of the intervention households and in those households, it was used only twice on average during the observation period (table 3.6).

Daily exposure to fecal bacteria

We estimated that children in the WASH and non-WASH arms consumed 13.8g and 15.25g of soil respectively. This corresponds to an estimated mean (95%CI) of 952(304-2926) and 1052(336-3233) E coli CFU's counts in the WASH and non-WASH arms (table 3.7)

Table 3.2: Environmental hygiene characteristics at the beginning and end of observation period

Characteristic	Beginning		End	
	WASH (n=89)	Non-WASH (n=90)	WASH (n=89)	Non-WASH (n=90)
Caregiver's hands visibly dirty	29(32.6)	31(34.4)	23(25.8)	29(32.2)
Baby's hands visibly dirty	40(44.9)	45(50.0)	56(62.9)	59(65.6)
Diapers or child's bottom not clean	24(27.0)	31(34.4)	35(39.3)	38(42.2)
Stagnant water within infant's reach*	60(67.4)	62(68.9)	57(64.0)	53(58.9)
State of kitchen				
Unwashed utensils	67(75.2)***	53(58.9)***	74(83.2)**	63(70.0)**
Uncovered utensils	40(44.9)	44(48.9)	47(52.8)	40(44.4)
Uncovered food	7(7.9)	11(12.2)	12(13.5)	8(8.9)
Spill on the floor (food or drink)	20(22.5)	18(20.0)	23(25.8)	23(25.6)
Poultry feces visible on kitchen floor	15(16.9)	11(12.2)	11(12.4)	17(18.9)
Animals in kitchen	19(21.4)**	22(24.2)**	13(14.6)**	25(27.8)**
State of yard				
Kitchen yard not swept	31(34.8)	40(44.4)	27(30.7)	34(38.2)
Area where child plays not swept	34(38.2)	37(41.1)	36(40.5)	32(35.6)
Poultry feces visible	62(69.7)	63(70.0)	70(78.7)	68(75.6)
Human feces visible	1(1.12)	1(1.1)	2(2.25)	2(2.2)
Other animals feces visible#	52(58.4)	60(66.7)	60(67.4)	59(66.3)

No=Number

*p<0.10 **p<0.05 *** p<0.01 ****p<0.001

*Any stagnant water within infant's reaches in kitchen or outside yard

Goat and cow feces

Table 3.3: Impact of the WASH intervention on mouthing soil, animal feces and visibly dirty dietary and non-dietary objects

Object	Mouthing or ingesting object at least once in 6 h observation period n(%)		Effect size (OR (95% CI))		Frequency of mouthing or ingesting object during 6 h observation period (mean (SD))		Effect size (IRR (95% CI)†	
	WASH ‡ (n=89)	Non-WASH‡ (n=90)	Unadjusted	Adjusted†	WASH#	Non-WASH#	Unadjusted	Adjusted†
Animal feces	1 (1.1)	2(2.2)	-	-	6(0.0)	3.5(3.5)	-	-
Soil	46(51.7)	63(70.0)	0.5(0.3, 0.9) ***	0.4(0.2,0.8) ***	4.7(4.0)	5.0(4.4)	0.9(0.6,1.5)	1.0(0.5,2.0)
Index child hands	84(94.4)	85(94.4)	0.9(0.3, 3.5)	1.0(0.3,3.9)	31.6(26.0)	36.3(24.3)	0.9(0.7,1.1)	0.8(0.7,1.1)
Food§	63(70.8)	69(76.7)	0.7(0.4, 1.4)	0.7(0.4,1.5)	12.6(13.5)	19.9(16.7)	0.6(0.4, 0.9) ***	0.6(0.4,0.9) ***
Stone/Stick/ Grass	56(62.9)	65(72.2)	0.7(0.4,1.2)	0.7(0.3,1.2)	8.9(9.8)	8.5(7.6)	1.1(0.7,1.6)	1.1(0.7,1.7)
Cup and spoon¶	46(51.7)	59(65.6)	0.6(0.3,1.1) *	0.5(0.2,0.9) ***	6.3(5.6)	5.9(5.3)	1.1(0.7,1.7)	1.1(0.7,1.7)
Clothes	30(33.71)	40(44.4)	0.6(0.4,1.7)	0.6(0.3,1.2)	3.4(2.8)	3.3(2.9)	1.1(0.6,1.9)	1.0(0.6,1.8)
Water/ beverages¶	22(24.7)	43(47.8)	0.4(0.2,0.7) ***	0.4(0.2,0.7) ***	4.8(3.1)	3.79(3.4)	1.3(0.8,2.3)	1.5(0.8,2.5)
Fruits§	26(29.2)	25(27.8)	1.1(0.6, 2.1)	1.0(0.5,2.0)	13.5(13.2)	15.46(11.6)	0.9(0.5,1.4)	0.9(0.6,1.4)
Body¶	20(22.5)	23(25.6)	0.8(0.4,1.7)	0.9(0.4,1.9)	2.0(1.5)	2.5(2.4)	0.7(0.3,1.7)	0.4(0.2,1.1) *
Shoes	11(12.4)	23(25.6)	0.4(0.2, 0.9) **	0.4(0.2,0.9) **	1.5(0.8)	1.7(0.9)	0.7(0.3,2.1)	0.7(0.3,2.1)
Household item¶	19(21.4)	22(24.4)	0.8(0.4, 1.7)	0.8(0.4,1.7)	2.6(2.6)	2.59(2.0)	1.0(0.4,2.7)	1.1(0.5,2.8)
Toys £	12(13.5)	11(12.2)	1.1(0.5, 2.7)	1.1(0.5,2.9)	4.5(3.8)	6.4(5.6)	0.7(0.3,1.5)	0.5(0.2,1.1) *
Other∞	89(100)	90(100)	-	-	14.0(13.8)	18.4(23.9)	0.7(0.5,1.1)	0.8(0.6,1.2)
All VD events	89(100)	89(100)	-	-	97.1(77.1)	89.4(59.7)	1.1(0.9,1.4)	1.1(0.9,1.4)

All mouthing events [¥]	89(100)	90(100)	-	-	228.4(86.9)	229.4(84.9)	1.0(0.9,1.1)	1.0(0.8,1.1)
<p>CI = confidence interval SD= standard deviation OR = odds ratio IRR=incidence rate ratio No.= number VD= visibly dirty * p<0.10 **p<0.05 *** p<0.01 ****p<0.001 ‡ Values in parentheses are no. of children with at least one visibly dirty- object mouthing event/ Total number of children † Adjusted for age, gender, mother's education, household size, type of kitchen floor # Mean number of dietary or non-dietary mouthing events during a 6-hour structured observation. \$ Refers to home-cooked food including Sadza, Green vegetables, Meat, groundnuts, round-nuts, porridge, beans, biscuit, rice etc. ⌘ The cup, spoon and plate used to feed index child Ⓔ Water, tea, milk, fruit juices § Apple, amarula, guava, mango, sugar cane, peaches, banana, orange ¶ Infant's body other than his/her hand Ⓒ Bowl, plate, teapot, knife, water glass, pot £ Toys or other play objects including empty plastic containers etc. ∞ Includes 58 different objects some examples are toothbrush, nail cutter, earphones Ⓔ All dietary and non-dietary mouthing events when the object was visibly dirty ¥ All dietary and non-dietary mouthing events observed during a 6-hour structured observation</p>								

Table 3.4: Impact of the WASH intervention on mother’s response to mouthing of visibly dirty objects

	Effect on the likelihood of an event				Effect on the frequency of event			
	Observation		Effect size		Number of mother instructions in 6 hours mean (SD)		Effect size	
	No. (%)		(OR (95% CI))				(IRR (95% CI))	
Mother’s response	WASH ‡ (n=89)	Non-WASH‡ (n=90)	Unadjusted	Adjusted†	WASH # (n=89)	Non-WASH# (n=90)	Unadjusted	Adjusted†
Mother instruction§ (all events)	53(59.55)	45(50.00)	1.4(0.8,2.6)	1.55(0.84,2.85)	2.4(4.2)	1.8(3.2)	1.3(0.8,2.2)	1.3(0.75,2.10)
Mother instruction§ (VD object)	34(38.20)	34(34.78)	1.0(0.6,1.8)	1.0(0.6,1.9)	2.4(4.2)	1.8(3.2)	1.0(0.6,1.6)	1.0(0.6,1.6)

CI = confidence interval OR = odds ratio IRR=incidence rate ratio No.= number VD= visibly dirty
 * p<0.10 **p<0.05 *** p<0.01 ****p<0.001
 ‡ Values in parentheses are no. Caregivers/mothers observed actively stopping child from ingesting object at least once/ Total number of caregiver/mothers
 † Adjusted for age, gender, mother's education, household size
 # Mean number mother instruction events during a 6-hour structured observation.
 § Mother actively stopping child from mouthing object in parentheses

Table 3.5: Impact of the WASH intervention on Index child hand washing

	Effect on the like hood of an event				Effect on the frequency of event			
	Observation No. (%)		Effect size (OR (95% CI))		No. of HW events in 6 hours mean (SD)		Effect size (IRR (95% CI))	
Hand washing event	WASH ‡ (n=89)	Non- WASH‡ (n=90)	Unadjusted	Adjusted†	WASH# (n=89)	Non- WASH# (n=90)	Unadjusted	Adjusted†
Any hand washing	71(79.8)	68(75.6)	1.3(0.6,2.6)	1.3(0.6,2.6)	1.9(1.7)	1.9(2.0)	1.0(0.7,1.3)	1.0(0.8,1.3)
Hand washing using running water	27(30.3)	23(25.6)	1.3(0.7,2.4)	1.3(0.7,2.5)	0.45(0.9)	0.4(1.0)	1.1(0.6,1.9)	1.0(0.6,1.9)
Hand washing with soap	23(25.8)	25(27.8)	0.9(0.5,1.8)	0.7(0.4,1.7)	0.4(0.8)	0.4(0.7)	1.0(0.6,1.8)	1.0(0.5,1.7)
No drying	66(7.2)	62(68.9)	1.3(0.7,2.4)	1.3(0.7,2.6)	1.7(1.6)	1.7(1.8)	1.0(0.7,1.3)	1.0(0.8,1.4)
Hand washing before eating	62(7.7)	55(61.1)	1.5(0.8,2.7)	1.5(0.8,2.8)	1.1(1.0)	1.0(1.0)	1.1(0.8,1.5)	1.1(0.8,1.5)
Hand washing after eating	28(31.5)	30(33.3)	0.9(0.5,1.7)	0.9(0.5,1.8)	0.4(0.8)	0.5(0.9)	0.8(0.5,1.5)	0.9(0.5,1.4)
Hand washing after crawling	4(4.49)	3(3.3)	1.4(0.3,6.3)	1.2(0.3,5.6)	0.1(0.2)	0.0(0.3)	1.0(2.2,4.8)	0.9(0.2,4.0)
<p>CI = confidence interval OR = odds ratio IRR=incidence rate ratio No.= number HW= Hand washing * p<0.10 **p<0.05 *** p<0.01 ****p<0.001 ‡ Values in parentheses are no. of children with at least hand washing event/ Total number of children † Adjusted for age, gender, mother's education, household size # Mean number of infant handwashing events during a 6-hour structured observation.</p>								

Table 3.6: Play yard use during the 6-hour observation period

Variable	n [€]	% [£]
Total number of children observed using the PY at least once	9	10.1
Total number of play yard events observed	19	100
Infant alone in the play yard	5	26.3
Other children in the play yard with infant	13	68.4
Mother inside the play yard with infant	1	5.3
Child playing inside play yard	13	68.4
Child eating/being fed inside the play yard	5	26.3
Child sleeping in play yard	1	5.3
Play yard visibly dirty	15	78.9
Play yard clean	2	10.5
Inside yard	19	100.0
Visibly dirty toys in the play yard	11	57.9
Nothing inside the play yard	11	57.9
Other things inside the play yard	9	47.4
Baby visibly dirty	9	47.4
Baby clean	10	52.6
Play yard used because baby crying	3	15.8
Play yard used because mother busy	8	42.1
Play yard used for other reasons	8	42.1
Play yard use stopped because baby was crying	11	57.9
Play yard use stopped because mother is playing with baby	6	32
[€] Number of events [£] No of events/ Total Play yard use events observed [§] No. of house-holds with at least one play yard use event / Total No of households who received a play yard		

Table 3.7: Daily exposure to fecal microbes

	WASH			Non-WASH		
	Mean hand/soil to mouth events	Estimated soil per episode (g)	Average E coli per day (95% CI)	Mean hand/soil/water to mouth events	Estimated soil per episode (g)	Average E coli per day (95% CI)
Soil-mouth event	31.6	7.9	545.1(174,1675)	36.3	9.0	621(198,1908)
Hand-mouth event	4.7	5.9	401(129,1251)	5.0	6.25	431(138,1325)
All events	-	13.8	952(304,2926)	-	15.25	1052(336,3233)

Discussion

We conducted structured observations of infants for more than 1000 hours to assess the effect of the SHINE WASH intervention on infant exposure to vectors of fecal-oral microbial transmission. We conducted this study to augment the primary analysis of the trial and provide some explanatory data based on structured observations. We found that mouthing visibly dirty dietary or non-dietary objects was very high in both the non-WASH and WASH arms, despite clear and age targeted messages to mothers in the WASH arms. The infant's own hands (94.4% in both arms) followed by food (70.8% in WASH and 76.7% in non-WASH arms) were the most frequently mouthed items. This is consistent with our earlier formative study in the same area that showed similar rates of these behaviors prior to the intervention. [13]

The intervention did not reduce the overall proportion of children who ingested visibly dirty objects; all children had at least one mouthing event of a visibly dirty object, despite intervention arm. However, the WASH intervention resulted in fewer children ingesting soil (51.7% in WASH compared to 70.0% in non-WASH arms). This reduction in soil ingestion was not due to the play yard; we observed play yard use in only 10% of the intervention households and no difference in mother's actively stopping babies from ingesting soil during the observation period. One possibility for this finding is that observations were completed at a relatively advanced age (18 months) and that mothers more actively stopped children from soil ingestion at younger ages, when babies may have been perceived to be particularly vulnerable. The observed difference could then be because children in the intervention arms had been taught and learned from a young age not to ingest soil.

The WASH intervention also reduced the proportion of children who mouthed visibly dirty objects in some categories of objects (baby cup and spoon, shoes, and water and beverages) (table 3.4). Given that all mouthing events (including both visibly clean and visibly dirty

objects) was not different across arms, the effect of the intervention may be reflecting caregiver's attentiveness in providing relatively clean objects to children in the WASH arms, making visibly dirty objects less available to them, rather than by discouraging the general mouthing of objects among infants.

Although we observed chicken feces in most households and in areas children were playing in both the WASH (78.7%) and non-WASH (75.6%) arms, we did not observe any child ingestion poultry feces during the observation period. These findings differ from our earlier work in Zimbabwe,[13] and other observation studies that have recorded children ingesting chicken feces in Peru [14] and Bangladesh. [15] [28] This could be because we observed relatively older children (18months) compared to the other studies where the children were less than or about a year old at the time of observation.

Concerning ingestion of E coli, we estimated daily exposure of mean (SD) 952 (304-2926) and 1052 (336-3233) E coli counts for the WASH and non-WASH arms, respectively. There is no guideline for safe level of Ecoli consumption from soil. The World Health Organization (WHO) and other bodies such as the CDC and the United States Environmental Protection Agency set the acceptable amount of Ecoli at 0 total colony forming units (cfu) in 100 mls of water.[29], [30] Food safety agencies set the amount of acceptable E coli in ready to eat food at less than 3cfu per gram of food. [31], [32] Based on the estimates in this study children consumed about 78 cfu per gram of soil which is higher than the acceptable levels in water and food. Therefore, although we achieved measurable effects on the fecal-oral pathways as intended and achieved contrast, the children in the intervention arms were still exposed to high levels of pathogenic bacteria. The Ecoli estimates in this paper are based on direct soil ingestion and visibly dirty hands only and do not take into account other visibly dirty objects. We also used the amount of soil needed to make a 12-month-old baby's hands visibly dirty. The average

age in this study was 18 months; hence this is a modest estimate of the amount of soil and therefore E coli that the children in this study were actually exposed to.

Play yard use was observed in only 10% of the intervention households and was used once on average during the observation period. In subsequent in-depth interviews, mothers in the WASH arms reported having used the play yard when their child was younger, but had reduced or stopped use by 11 months, the age of the youngest child in this sub study. (SHINE unpublished data). In other areas where play yard use is common [33], [34], the use and frequency decrease and stop around the same age period (9-14month) period reported by the mothers in our study.

Successful BCC interventions are designed to trigger specific motivators and several researchers have suggested disgust as a strong motivator for hygiene behavior change.[26], [35] Some researchers have also suggested incorporating parental aspirations for their children in BCC messages to trigger nurture and motivate caregivers to take up interventions.[26] The interventions in this study were developed to use both of these as primary drivers of behavior change.²²⁻²³ Nevertheless, we were unable to demonstrate an effect of the intervention on infant hand washing practices, including the use of soap or running water. This might partly be explained by the fact that the hand-washing device provided and promoted during the study (the tippy tap) was not designed for infant hand washing. Infants were not old enough to use the tippy tap on their own and none of the observed infant hand washing events in this study was done at the tippy tap. Hence interventions to promote infant hand washing may benefit from in-depth formative research to understand hand-washing devices caregivers are more likely to use for infant hand washing. Another potential explanation could be that the duration and intensity of the intervention may not have been sufficient to result in behavior change. Studies that have shown an impact on hand washing behavior in adults employed interventions

that were delivered with high frequency from daily to fortnightly. [36] Our study had monthly intervention contact, which may not have been sufficient for intervention impact. Our formative work also showed that infant hand-washing was rare in rural settings in Zimbabwe.[13] Hence the intervention uptake for this rare behavior may not have been sufficient to detect a difference.

Strengths and limitations

To our knowledge this is the first study to use in-depth observation methods to evaluate a WASH intervention that was developed to target pathways of fecal-oral contamination in children. Preventing fecal-oral transmission in children is uniquely challenging and this study not only addressed this problem but also provided in depth observations to evaluate what actually went into a child's mouth as opposed to relying on caregiver reports as a proxy for infant exposure to fecal contamination. Other strengths of the study are its randomized design, and its large sample size for an in-depth evaluation method.

Our results should be interpreted within the context of some limitations. First, we did not include microbiological analysis to quantify exposure to fecal bacteria objectively; instead we used the visual condition of objects as a proxy for contamination and data from a previous study to quantify the exposure. Our intervention focused on separating the child from and thus preventing them from mouthing contaminated objects. Our rationale for the intervention included findings from an earlier baby observation study in the research area, which found high levels of contamination in soil, child's hands and other dietary and non-dietary objects mouthed by children.[13] Other studies have also shown similar levels of contamination in similar objects in Bangladesh. [16], [37] Another study in Tanzania used *E. coli* as an indicator of fecal contamination and estimated that 97% of the total fecal matter ingested by a child resulted from hand mouthing.[38] We observed poultry feces in about three-fourths of both WASH and non-

WASH households. We also observed cow/goat feces in about two-thirds of WASH and non-WASH households. Considering these contaminated playing environments for children in our study as well as the high proportions of children and frequency of mouthing visibly dirty mouthing objects, the use of visibly dirty mouthing events as a proxy may be a good indicator for fecal-oral contamination in these children.

A second limitation of our study is that the observers were not blinded to study arm because of the nature of the intervention. However, there was rigorous training at the beginning of the trial as well as ongoing spot checks and support during the data collection period to ensure that all observers did not deviate from the observation protocol. A third limitation of our study is that visits were announced and the presence of observers in the households may have led to caregivers modifying their behavior. However, the primary outcomes for this study were mouthing behaviors in children, which are unlikely to have been modified. We also did not observe any differences in household, caregiver and infant characteristics at the beginning of the observation period compared to the end of the observation period when caregivers might have been more likely to be engaging in their normal behavior (table 3.2). A fourth limitation is that we observed children's mouthing behaviors on a single day within a 3-month time period, and therefore we could not capture day-to-day or seasonal differences in these behaviors. Also, the babies in this study were relatively older within the age period of the intervention. Mouthing behaviors in children are age dependent and are more frequent in younger ages [1], [28], [39] hence we may have missed the age of greatest intervention impact. Finally, our study had limited statistical power for some of our outcomes. Our sample size calculations were done to detect a reduction in soil ingestion only and not the frequency of mouthing events in those children who ingested soil.

Conclusion

We found that a WASH intervention designed to minimize ingestion of fecal microbes in infants by targeting mouthing behaviors through the provision of all the necessary materials including playpens and intensive behavior change communication resulted in some reduction in the mouthing of soil and visibly dirty dietary and non-dietary objects in the intervention arms. While children in the intervention arm were significantly less likely to ingest soil and some visibly dirty objects there was still substantial ingestion of soil and visibly dirty objects in the intervention arms. Three recent trials, which include the SHINE trial, showed that WASH failed to reduce stunting and there was evidence of substantial fecal-oral microbial transmission. [24], [40], [41] The results of this in-depth observation confirm other observations by showing that fecal-oral contamination was still substantial in the WASH arm and the reductions noted might have been insufficient to detect an impact on health outcomes. Additionally, this study showed high rates of visibly dirty infant hands and no impact on infant hand washing. We conclude that further research to develop and evaluate novel and feasible approaches to improve hygiene behaviors in children under twenty-four months needs to be under taken, given the important negative role of pathogen ingestion in infants and young children.

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CHAPTER 4

CAREGIVING AND INTERVENTION UPTAKE, AN EXPLORATION OF WOMEN'S EXPERIENCES WITH NUTRITION- SPECIFIC AND NUTRITION- SENSITIVE INTERVENTIONS IN RURAL ZIMBABWE.

Abstract

Background: Care is a critical underlying factor for improving child growth. Health interventions usually target caregiving practices and are expected to influence women's caregiving decisions. **Objective:** We aimed to explore, among a group of women who had interacted with caregiving interventions, (1) women's caregiving perspectives, priorities and experiences, and (2) motivators and barriers to the uptake of interventions aimed at improving health and nutrition behaviors. **Method:** We conducted 40 in-depth interviews with a purposively selected sample of caregivers of infants (aged 12 to 18 months old) using a semi-structured interview guide. All participants in the interviews had received one or more interventions in the Sanitation Hygiene Infant Nutrition Efficacy (SHINE) trial, which included nutrition-specific and nutrition-sensitive messages delivered one-on-one by village health workers (VHWs) in the participant's household. All interviews were audio recorded, transcribed and translated, and then analyzed for themes and sub-themes, using standard coding procedures for text analysis. **Results:** Based on women's narratives in response to broad, open-ended questions, barriers and facilitators of reported appropriate child care practices and intervention uptake were classified into four major themes: (1) caregiving environment (including sub-themes around perceived child health and well-being, family involvement, social support, cultural/social norms, resources and husband involvement), (2) maternal capabilities (with sub-themes around caregiver knowledge, self-efficacy and time, (3) intervention messages (with sub-themes around perceived ease/complexity of intervention, mode of delivery and duration of intervention lessons), and (4) intervention delivery agent (with sub-themes around perceived knowledge of the VHW, communication skills and

reliability). We found that the most significant factor influencing caregiver's priorities, how they perceive themselves as caregivers as well as their interaction with the interventions, was a nurturant caregiver response driven by the women's need for a healthy child. **Conclusion:** Our results show that in rural Zimbabwe, caregiving decisions and, hence, intervention uptake is influenced by multiple factors, but the underlying dynamic can be characterized in terms of the interaction between caregiver actions and child feedback.

Introduction

The UNICEF conceptual framework presents “care” as a critical underlying factor that is important in child growth. [1] Caregiving consists of protecting, nurturing and comforting actions. [2] It is dynamic and is influenced by various social supports and constraints, including a caregiver’s experiences, interactions with her child and the caregiving environment. Caregiving constantly changes over the course of the caregiving experience, and a mother develops caregiving practices with a specific child through the process of “maternal role attainment”, which includes (a) developing a relationship with the infant (b) acquiring competence in caregiving tasks and (c) experiencing satisfaction with the maternal role that motivates, regulates and sustains it. [2] Reasonable workloads and availability of adequate time are also important contributors influencing the care practices that a mother develops, adopts and sustain.[3] Child health interventions are delivered and expected to work within this dynamic context. Hence it is important to understand how interventions are best adapted to fit within a given caregiving context.

The Sanitation Hygiene Nutrition Efficacy (SHINE) was a 2x2 cluster randomized trial designed to test the independent and combined effects of nutrition and water, sanitation and hygiene (WASH) interventions on stunting and anemia in rural Zimbabwe.[4] A specific emphasis in the trial was caregiving, and the interventions were designed and implemented to strengthen and support caregiving practices around infant feeding and WASH. The interventions aimed to motivate mothers to adopt and sustain good infant feeding practices by supporting caregiving priorities for women in rural Zimbabwe. Women’s caregiving practices and priorities were identified through formative research and examined through an embedded process evaluation, which occurred throughout the project implementation.

The interventions were designed to modify the caregiving environment by providing inputs

such as food supplements, a Blair VIP latrine, handwashing soap, water-treatment solution and a play yard. They also included activities that were expected to tap into the mother's motivational psychology by triggering specific emotions (e.g. nurture or disgust) to influence the mother's child-care decisions. [5], [6] The intervention therefore potentially shaped the mother's caregiving expectations and intentions and might affect their satisfaction with their role as caregivers either positively or negatively. Participation in SHINE required a substantial time commitment from caregivers, including receiving behavior-change communication (BCC) messages, which took on average 1 hour per visit and were delivered in 15 visits from pregnancy until 18 months post-partum. Women in rural Zimbabwe usually have multiple responsibilities that leave very little room for any additional activities. [7] They are typically involved in unpaid subsistence farming, carrying water, gathering wood used for fuel, cooking and other household chores, in addition to activities related to child care. [7], [8] and they may also be involved in some informal work. Women's total work has been estimated to be around 18 hours a day and, unless efficiencies are found, a new activity is only added at the expense of another activity. [8]

The SHINE trial included a nested qualitative process evaluation to understand caregiving practices and to explore how the interventions interacted with the mother's caregiving environment to influence intervention uptake and impact. This process evaluation explored mother's perspectives on caregiving and their own evaluations of their caregiving competence. Caregiving competence is defined as the expression of motivation, judgment and skills sufficient to meet the necessities of caregiving [2]. A mother's evaluation of her competence in performing caregiving tasks reflects what she expects of herself as a caregiver and of her infant, as well as indicating what she intends to do as a caregiver [2]. These expectations and intentions –“components of a mother's working model of caregiving – develop through

experience and dynamically regulate and organize perception, interpretation of information and immediate and anticipated caregiving action” [2].

The objectives of the study reported here were: (1) to assess the mother’s perspectives on caregiving and their own evaluation of their caregiving competence, (2) to explore the caregiver’s perspective of her caregiving environment and identify factors she considered to be important within that environment, (3) to explore how the interventions interacted with the mother’s caregiving environment and identify factors that influenced the mother’s caregiving decisions, and (4) identify motivators/facilitators and barriers to intervention uptake that may be important for outcomes of nutrition-specific and nutrition sensitive interventions.

Methods

Overview of the SHINE trial

The trial was conducted from November 2012 to April 2017. [4] Briefly, SHINE was a community-based, 2x2 cluster randomized trial to compare the independent and combined effects of a WASH and complementary feeding (CF) intervention on stunting and anemia among rural Zimbabwean infants. Village health workers (VHWs) conducted pregnancy surveillance to identify women who became pregnant between Nov 22, 2012, and March 27, 2015. The study area was divided into 212 clusters and each cluster (defined as the catchment area of 1-4 VHWs) was randomized to one of four intervention arms, standard of care (SOC), complementary feeding (CF), WASH and a combined WASH + CF intervention arm. Pregnant women (n=5280) were enrolled into the trial between 8-16 weeks gestation from two rural districts (Shurugwi and Chirumhanzu) in central Zimbabwe. All enrolled women received 15 scheduled intervention visits from study entry during pregnancy to 12 months postpartum with continued visits up to 18 months postpartum to deliver intervention inputs (soap, water guard and small-quantity lipid-based nutrient supplement (SQLNS)).

The SHINE interventions have been described in detail elsewhere. [4]–[6] In summary, all intervention arms received the SOC intervention which included standard messages from the Ministry of Health and Child Care (MOHCC) on family planning and immunizations and basic hygiene. They also received a strengthened exclusive breast feeding (EBF) intervention that was timed and targeted to the developmental stage of the child. In the CF intervention arm, women received BCC messages to improve the quantity and quality of complementary food. Messages covered preparation of thick porridge, dietary diversification, responsive feeding and feeding during illness. In addition, participants also received a small quantity lipid-based nutrient supplement (SQLNS) from 6 to 18 months. In the WASH arm, participants received BCC messages about safe stool disposal, handwashing with soap (particularly for infant), point-of-use water treatment and ensuring children drink only treated water, preventing children from eating soil and animal feces as well as hygienic handling and preparation of complementary food. In addition, they received a Blair VIP latrine, two handwashing stations or tippy taps, a chlorine water treatment solution (water guard) and soap for handwashing.

Based on the assigned intervention arms, research staff trained all VHWs to deliver intervention messages to participants in one-on-one sessions at the participant's households. All VHWs received two weeks training on research ethics, communication skills and a refresher of standard of care messages and were introduced to updated EBF BCC lessons. VHWs in the CF and WASH interventions received an additional 2 weeks of training, while those in the combined arms had an additional 4 weeks training on arm-specific messages. In addition, VHWs also received additional one on one and group training sessions from research staff monthly or more often depending on their performance. VHWs were shadowed by research staff for all visits when they first introduced new content to ensure that all messages were delivered completely and to help address any questions. Lessons included messages and

interactive tools and activities, previous lessons were reviewed before introducing new information to create a sequenced integrated longitudinal intervention. After 12 months, VHWs continued monthly visits to deliver inputs and provide informal reminders.

The SHINE trial findings showed high fidelity of intervention delivery as well as uptake of interventions by women in all intervention arms. 98% of all WASH households received a Blair VIP latrine and nearly 80% or more of the planned deliveries of soap and water guard. Among CF households, 79% received $\geq 80\%$ of planned deliveries of the small-quantity lipid-based nutrient supplement. Among households in the WASH groups and CF groups, mothers received a median of 15 (IQR 13–15) of the 15 intervention visits scheduled between enrolment and 12 months postpartum. At the 12 months post-partum visit when intervention uptake was assessed, there was low frequency of open defecation among household members in the WASH groups (1% compared with 41% in non-WASH groups). In 86% of WASH households the latrine had a well-trodden path indicating latrine use, 84% of households in the WASH groups had a handwashing station with observed soap or rubbing agent and water compared with 2% of households in non-WASH groups. 87% the women in the WASH groups reported that they usually treated their drinking water. CF arms also reported a higher proportion of children meeting minimum dietary diversity, consuming animal-source, iron-rich, and vitamin-A-rich foods in the previous 24 hours. There was also reported high usage (93%) of the SQLNS in the CF groups. [9]

Sampling and data collection

For this sub-study, we used purposive sampling [10] to recruit a subsample of the trial participants for in-depth interviews. Women were sampled to represent all 4 intervention arms equally and to reflect diversity in levels of intervention uptake and use. Forty women were selected for this study, 10 from each of the intervention arms, which included women who had

high adherence and those with low adherence to the intervention. The sample size for this work was based on feasibility and general experience in in-depth narrative interviews, in which data saturation is often achieved with about 20 interviews.

In-depth interviews were conducted between February–March 2017 by one researcher (DF) who is a native speaker of the local language (shona) and has PhD level training in conducting in-depth interviews. The interview guide covered questions related to caregiver’s experiences, perceived competence and definition of caregiving. It also covered specific questions about their experiences with the SHINE interventions. All interviews were conducted in shona. To reduce social desirability bias, the interviewer had not participated in any of the primary trial activities and conducted interviews separately from any of the other trial activities. The interviews were conducted at the participant’s home or in a place the participant was comfortable being. The interviewer assured the participants that the aim of the discussion was to learn from the mothers about their experiences interacting with the SHINE interventions, both positive and negative. The researcher kept a field diary where key themes and ideas from each interview were recorded. All interviews were audio recorded.

Data preparation and analysis

The interview audio files were transcribed and translated by one research assistant. 10% of the audio files were randomly selected and transcribed and translated by second researcher to ensure that all transcripts were reliably translated.

Transcripts were then analyzed thematically, based on the constant comparative method. [11] One researcher read through each interview once to understand the structure and underlying aspects of the data before creating a code book. For each transcript a list of code labels and definitions was compiled. All emerging themes were checked with the field diary notes. A code

book was created, which consisted of code labels and definitions, as well as inclusion and exclusion criteria to ensure coding consistency. [12] The interview transcripts were then coded and recorded in Atlas.ti[®]. To determine replicability of the coding an independent researcher coded a random sample of 10% of the transcripts.

All the respondents provided written informed consent before enrollment. Ethical approval to conduct this study was granted by the Medical Research Council of Zimbabwe and the Institutional Review Board of Johns Hopkins University Bloomberg School of Public Health. The SHINE trial is registered at ClinicalTrials.gov Identifier: NCT01883193.

Results

Participants

We interviewed 40 women 10 from each of the four intervention arms. Their mean age was 28.3 (range 18.5-40.5), years of education was 9.8 (7-13) and parity was 4 (1-6). Average household size across all participants was 4 (range 2-9) and child age in months was 20.7 (18.2-22.4). The sample characteristics are summarized in Table 4.1 by study arm.

Table 4.1: Participant characteristics[#]

Study arm	SOC (n=10)	CF (n=11)	WASH (n=9)	WASH + CF (n=10)
Child Age (months)	20.9(19.5-22.4)	18.2(18.2-21.9)	20.3(19.3-21.7)	21.3(20.6-21.9)
Caregiver Age (years)	27.6(18.5-37.6)	31.1(19.2-40.6)	25.5(18.6-37.5)	27.5(27.5-37.5)
Caregiver education (years)	9.1(7-11)	10.2(9-13)	10.0(7-11)	9.9(7-13)
Household size	4.6(3-7)	4.6 (2-9)	4.4(2-7)	4.4(2-7)
Parity	2.1(1-4)	2.3(1-3)	1.9(1-6)	1.9(1-3)

[#] all values are mean (min-max)

Caregiving

Emic definition of caregiving: Women's definitions of caregiving included a range of activities including bathing the child, feeding and hygiene, to health and general wellbeing of the child. Many women expressed the idea that caregiving centered around the baby's needs and the mother's actions in response to those needs. Reported caregiver responses included provision of food, clean clothes, clean and safe play area, safe and nutritious food, and bathing, cleaning for and doing laundry for their child to ensure good health. Table 4.2 summarizes the key themes that emerged around women's definition of caregiving. The women also mentioned that caregiving required patience in providing care and protecting the child and caregivers needed to be able to prioritize child needs.

Perceived caregiving competence. We asked women to rank themselves on a caregiving scale of 1 to 5, with 5 being the best caregiver and 1 the worst caregiver. 65% of the mothers ranked themselves as 5, another 50% ranked themselves as 4, and 5% ranked themselves 3 (Table 4.3). No mother ranked herself as belonging on the lowest 2 ranks. Mothers who ranked themselves highly reported that they felt like they had the knowledge and ability to perform adequately as caregivers, follow advice from VHWs, and had healthy children. Their assessments of their perceived competence were related to their assessments of their child's health and well-being. Many of these mothers mentioned that they had few hospital visits, their children were rarely sick and were developing well. Women also ranked themselves highly because of how they assessed their communities' views of them. They noted that other members of the community commended their caregiving efforts or their child's health.

Women who ranked themselves as four or three mentioned similar traits. However, they felt they did not deserve the highest rank because of their failure to completely eliminate child behaviors that they perceived to be negative behaviors, such as child eating soil, or their own

time constraints, which limited the quality of child care activities, or not adopting lessons from the VHW. They also attributed their lower self-scores to lack of resources. When asked what sort of mothers should be given low ranks, they mentioned “ lazy women who are unable to work to provide for their children,” women who do not immunize their children, and those with sick children. Table 4.3 summarizes the key themes that emerged around women’s perceived caregiving competence.

Source of caregiving knowledge. Mothers listed several sources of caregiving information, including VHWs 40 (100%), clinic 34 (85%), church 18 (45%), mother in law 16 (40%), mother 12 (50%) , husband 13 (32.5%), neighbors 6 (15%), elders in the community 2 (5%), grandmother 6 (15%), sister in law 4 (10%), NGOs 2 (5%) father in law 1 (2.5%), work 1 (2.5%), books 1 (2.5%), aunt 1 (2.5%). When asked which of these sources was the most important, most women 33 (85.5%), considered VHWs, a quarter 10 (25%) considered the local clinic and 3 (7.5%) considered the mother in law, and 3 (7.5%) considered the mother and less than 5% considered any of the other sources of information as important. No women considered the fathers-in-law, work, books, aunt, radio or NGOs to be important sources of child care information.

VHWs were considered to be the most important source of childcare information because they were perceived as professionals, knowledgeable, lived close to the women, and hence, were readily available (table 4.4). Although local clinics were considered knowledgeable, women felt that they only saw them rarely (i.e. when they went for immunizations or other health problems.) Women also reported that when they received child care knowledge from the clinic, the nurses did not take time to explain issues or address their questions adequately in the way VHWs did. While child care advice from other members of the family was important to women, they considered the knowledge from the VHWs as superior because they felt that some of the

family members provided knowledge that was “outdated” or “not reliable”. The women reported that although they asked for and received advice from their mothers and mothers-in-law, they felt autonomous with respect to making infant feeding decisions. They also felt like they could easily decline the advice offered by others without compromising relationships

Women’s interaction with SHINE interventions

Women were generally positive about their experiences with the study interventions. They reported that they had enjoyed receiving and using the lessons, and all except one said they tried the interventions. The one woman who had not tried all the interventions reported that she moved out of the study area at some point and missed some of the lessons.

Facilitators and barriers to intervention uptake:

The key themes and subthemes for the facilitators (table 4.5) and barriers (table 4.6) of intervention uptake that emerged can be summarized in 4 categories, (1) the intervention delivery agent, (2) the actual intervention messages (3) caregiving environment and (4) maternal capabilities

(1) *Intervention delivery agent:* The experience receiving the lesson with the VHW was the main driver for the initial uptake of behaviors. Women appreciated VHW’s way of teaching, which they described as new to them. They also felt that the VHWs were very knowledgeable professionals, who were patient, polite and respected women’s time by coming to all scheduled visits, interacted with them in a respectful manner, and took the time to fully explain lessons and address all questions. This made women curious and motivated to try these lessons to see the health benefits for their children. However, one woman reported having problems with a VHW who did not show up for lessons and did not deliver intervention inputs on time, which hindered her from adopting interventions.

(2) *Intervention messages:* Women reported that the lessons were simple and were delivered in a way that made it easy for them to understand the lessons. They noted the provision of reminder charts, which helped them to remember the lessons after the VHW left. Some women in the CF intervention arms reported problems with children initially refusing to eat certain foods, however this changed when they consistently offered the food to the children. Women in the WASH arms reported having problems maintaining behaviors, particularly stopping children from eating soil, because when babies were older and more active, they were unable to check on them constantly. Although most women expressed satisfaction with the duration of the lessons and even suggested that more time would have been desirable, some also felt that the time it took to receive the lessons interrupted their normal household chores, particularly in the rainy season when they had to spend the majority of their time tending to their fields.

(3) *Caregiving environment:* Once the lessons were adopted, several aspects of the caregiving environment helped women sustain the behaviors. The strongest influence on sustaining the desired behaviors seemed to be caregivers' perceptions about child health and well-being. Many of the women reported that they sustained the new behaviors because they could see benefits on the growth, health and development of their children. Many women expressed that their children were growing and developing better than their previous children. Women also continued to use the interventions because they were afraid of losing the health benefits they were observing and hence end up in "harmful situations". Another motivator for sustaining behaviors was to prevent diseases in their families, women expressed the idea that adopting interventions meant fewer visits to the hospital which enabled them to save on medical bills. Women also reported that availability of resources, those provided by the study and those from their families were facilitators for their ability to continue to adopt behaviors. However,

a lack of resources was also mentioned as a barrier to intervention uptake, particularly by women enrolled in the CF arms who felt they could not afford to provide the diverse diets, as encouraged by VHWs.

Social support emerged as a facilitator for continued practice of the intervention components. Support was manifested as support from spouse, other family members and neighbors and friends. The support women received from their husbands and family members included practical support, such as making resources available for child care, reminding them about specific behaviors and helping with childcare. Families also provided emotional support, such as encouraging and motivating women to continue to receive lessons, as well as respecting their child care decisions. Family involvement, however, also served as a barrier to intervention uptake, particularly for interventions that contradicted social or cultural norms. An example is exclusive breastfeeding, for which some family members, especially older members of the family (i.e. mothers-in-law or grandparents) acted as barriers when they believed that children would not get sufficient “food” if they were fed only breast milk.

Respondents reported that friends and other members of the community discussed the intervention messages with them and reminded them about key behaviors. A sense of belonging in the community was important to the women, and they were motivated to adopt behaviors because they felt that other women were also doing these behaviors. They were also motivated to sustain behaviors by receiving validation from the community that they were “good caregivers.” Women reported that they felt a sense of pride when other people in the community viewed their care-giving behaviors positively, and this motivated them to continue with the interventions. They also

perceived their children to be doing better than other children in the community, which led to the perception in the community that they were experts.

(4) *Maternal capabilities.* Other facilitators to intervention uptake were specific caregiver characteristics that reflect maternal capabilities, including self-efficacy, autonomy, knowledge and time. Almost all women felt that they had knowledge and were capable of acting on the lessons. They reported that the lessons were easy and acting on them was something that they were capable of doing if they put their mind to it. They saw interventions as not only providing new information, but also information on how to do things better, which made them more confident. Almost all women expressed their autonomy with respect to child care decisions and regarded themselves as the sole deciders for acting on the lessons. They dismissed the importance of husbands and other family members, with the explanations that they themselves were primarily responsible for child care because they spent more time at home. They also reported that forgetting lessons and having limited time to balance their other chores and caregiving activities may have negatively impacted their ability to take up and use lessons.

Unintended consequences of the interventions: Paradoxically, in view of the foregoing findings, a key theme that emerged was the negative effects of the intervention on mothers' perceptions of their own caregiving ability. Respondents expressed a sense of helplessness if they did not have the resources to adopt some of the interventions. They expressed feeling less confidence in themselves or their abilities as mothers or caregivers. One mother cried during the interview and several women said they felt deeply hurt by not being able to take up these lessons. Women also commented that they felt badly about themselves as caregivers because the lessons gave them knowledge on which they were unable to act. One caregiver even suggested it would have been better not to know about the health benefits of the interventions

that she was not able to provide for her child (table 4.7). Another caregiver expressed her worry that after the end of the study she would not be receiving Water Guard, and this would negatively affect her children's health. Her response to this concern was to pour all of her Water Guard into the well, as a single dose. She knew this would not be very helpful; however, she said it made her feel she was at least doing something for her children, which was better than not doing anything at all.

Respondents' recommendations for improving the interventions: Although women were generally satisfied with the way the interventions were delivered, they provided some suggestions for improving women's experience. Although all the women reported positive feelings about the one-on-one delivery of the lessons in their homes as it allowed them to freely ask questions without being judged, some suggested that adding a group lesson would enhance the experience by enabling women to share and trouble shoot with other women. They suggested this would enable women to share ideas and help those who are struggling with the lessons. Making the lessons available not only to pregnant women was also mentioned as a way to help others (e.g. in the family) understand the importance of the interventions for child care. They also emphasized that lessons should be delivered in an approachable, patient and respectful manner as this helped them be more receptive to the content. Some respondents said that it was sometimes difficult for them to make decisions without their husbands, hence also involving them may help make lessons more effective. Lastly, women recommended providing incentives, such as building latrines and handwashing station, to help with the behaviors. Illustrative quotes are summarized in table 4.8.

Discussion

The results of this study illuminate the emic perspectives of caregivers in Zimbabwe about caregiving and caregiving priorities, their ideas about caregiving competence and their

perceptions about how their caregiving environment influenced their interactions with the SHINE interventions. Our results suggest that successful child care-giving interventions depend on a complex interplay of these different factors (i.e. caregiving priorities, perceived competence and caregiving environment). The individual and combined contribution of each of these factors to women's capacity to adopt and sustain recommended behaviors present challenges and opportunities that call attention to the importance of in-depth understanding of context for designing child-care interventions that can equip them with knowledge, skills, and conducive environments.

Caregiving priorities and perceived caregiving competence

The women in our study universally described their caregiving priorities as being driven by a desire for the health and well-being of their child. This nurturant caregiver response to the child is universal across cultures. [13] In our study we saw that it influenced how women perceived themselves as caregivers and how they interacted with the SHINE interventions. Given its importance, this fundamental cultural concept can be used as a “trigger” to facilitate child-care-related behavior change. A trigger is defined as a stimulus for thinking about a related concept or idea, which can then be used to help people to initiate a new behavior. [14] Many child care interventions such as infant and child feeding focus on addressing knowledge gaps and equipping women with critical knowledge and skills to improve child health.[15], [16] Our findings reveal that the women who received the intervention felt that receiving new knowledge and skills helped them to adopt all of the interventions. The results also suggest that beyond providing project recipients with knowledge and skills, the project tapped into cultural triggers to support behavior change. Women in this study reported the feedback they were getting from their children and the need for continued benefits on child health and development as the main trigger for sustained use of interventions. We interpret this as evidence for the importance of psychological triggers in the SHINE interventions. This, in turn, suggests that

embedding psychological triggers of nurture in interventions may be important for adoption of new practices for care-giving. However, it is important to also note that although psychological triggers can be important for the adoption of childcare behaviors, they also have the potential to negatively impact women's perception of their own ability as caregivers which can undermine caregiving or impact women's mental health. As discussed earlier, women in this study valued having a healthy child and this impacted their caregiving priorities including how they viewed themselves as caregivers. Use of psychological trigger can shift the women's ideal for what they consider a healthy child and if they fail to attain this it may impact their own mental health.

Although the use of emotions and psychological triggers to motivate behavior change has been gaining traction in WASH literature, these triggers have usually been focused on negative concepts, primarily "disgust". [17] [18], [19] This in part reflects the fact that many WASH interventions have mainly focused on changing behaviors at the household or community level, with less emphasis on child well-being and care. Importantly, disgust did not emerge as a trigger for WASH behavior in the in-depth interviews. This might result from the fact that the participants received baby WASH messages, which focused on children, and WASH behaviors related to babies invoke less disgust. [20] Nutrition interventions, on the other hand, have focused mostly on increasing knowledge, awareness raising and/or sharing information and, in comparison to WASH interventions, have made less use of participatory approaches that harness emotions, in particular nurture, to improve intervention uptake.[21]

Barriers and facilitators to intervention uptake

Through our formative research, we identified several facilitators and barriers to intervention uptake[20], [22]-[23]. Although this study differed with our earlier work in that women interacted with the intervention longer compared to our formative research, several of our

findings were similar. The factors facilitating intervention uptake and use were those related to the VHW, the actual intervention, the caregiving environment and maternal capabilities.

In this study, the primary driver for initial uptake of the intervention was the interaction between the VHW and the mother. VHWs were perceived as knowledgeable, professionals in the field and they were also considered respectful, patient and reliable in providing intervention messages. Women reported that the initial adoption of lessons was due, in part because of the quality of the lessons that they received from the VHW. Their assessments included general communication skills as well as the intervention specific message delivery. The importance of the interaction between the VHW and the mother was prominent in this context and should be considered in training community health workers. The benefits of high-quality counseling have been identified in other settings [24]–[26], however, many health and research programs that use VHWs or community health workers have not provided training on counselling skills, focusing instead on specific child care interventions with little emphasis on general communication skills. [16], [27]

Once interventions were adopted, several aspects of the caregiving environment influenced sustained use. These included child feedback, family support, social support, social affiliation and resources. Our results suggest that the most influential factor was child feedback, specifically mother's perceptions of positive changes in child health, development and general well-being that caregivers observed in their children as a result of the intervention. Women reported that children were doing better than their previous children and other children in the communities. This motivated them to continue using interventions, helped them justify their caregiving decisions to their families and also motivated their husbands to support them and make resources available for child care. This is an example of "perceived benefit," and this is a key construct in the Health Belief Model [28], which has been shown to influence behavior

across a variety of contexts and interventions ([29]–[33]). An in-depth understanding of what women in different contexts perceive as “benefits” is likely to provide knowledge that can be leveraged in developing behavior change messages that address women’s aspirations and hence encourage intervention uptake and sustained use.

Social support from community members as well as family members was identified as an important factor supporting continued intervention use. Husbands and other family members in this study provided practical support, such as helping with child care, making resources available for childcare and reminded women to adopt intervention messages. They also provided emotional support, such as encouraging women and supporting decisions to adopt interventions. Social support has been shown to be important in supporting maternal caregiving behaviors in different contexts and interventions. [34]–[36]. This study supports and add to this body of knowledge.

We also found that families could also play a negative role by discouraging mothers from adopting some of the intervention messages, particularly those that went against social cultural norms. Mothers everywhere interact with and have to make decisions about child care messages that are diverse and often conflicting [37] Social and cultural norms have been noted to be an important aspect driving women’s child care decisions [38]–[42], and studies in different settings have shown that women are less likely to adopt behaviors that are not accepted in their families and communities. [43], [44] On the other hand, we also noted that our respondents reported going against social norms and expectations by taking up some of the behaviors. One explanation for this is that they had sufficient knowledge to feel confident about their choice. The interventions the women in this study received were developed using extensive formative work that identified and addressed key cultural misunderstandings, [4], [13], [14], [21] hence providing women with the knowledge that they could use to explain their

child care decisions to their families. This finding highlights the importance of adequate formative research to understand culture and context when designing effective interventions for child health research and programs.

Lack of resources emerged as an important barrier to intervention uptake and, although women mentioned that it limited their choices and what they could provide for their children, it seemed to have an even greater effect on the mothers' perceptions of their own caregiving competence. Women ranked their caregiving competence lower as a result of their perceived inability to provide their children with specific food or provide inputs to take up intervention messages. They also reported a general helplessness in their ability as caregivers. Complementary feeding intervention studies and programs have repeatedly shown that poverty limits food choices, and poverty is associated with inadequate diets during the period of complementary feeding and poor child nutritional status[39], [46]–[48]. Some studies have shown that lack of resources can affect mother's perception of their caregiving practices even for behaviors that do not need provision of additional resources. In a study in Kenya, financial restrictions affected women's perceptions of their own breastfeeding competence; women who lived in food-insecure households felt less competent to breastfeed infants younger than 6 months sufficiently compared to those in food-secure households.[49] Kimani-Murage et al. 2015 [36] reported similar findings from Nairobi slums.

In our study women who received the intervention messages and were unable to implement them because of financial constraints or lack of resources expressed a feeling of deep hurt and helplessness over their inability to adopt the interventions. This was particularly true for women who were enrolled in CF arms and were therefore receiving BCC messages that encouraged them to use locally available food to improve the quality and quantity of infant foods. This finding has implications for providing BCC in food insecure regions without also

providing supplementation or supplemental foods. Engle, Lhotska, and Armstrong, [1] posit that care practices cannot occur without resources to provide the care and that focusing on care practices without resources may result in the blaming of the mother for inadequate care. Given the importance of having a healthy and well-rounded child for the women in our study, the implications are far-reaching with respect to women's mental and physical health. Moreover, in view of the association between maternal depression and stress, and poor child health outcomes in a number of different contexts. [34], [50]–[53] it also has implications for child health. For example, Begin and Frongilo,[54] found that caregiver's level of satisfaction with life and caregiving was associated with children's height-for-age. Available interventions for women's health care are focused mostly on addressing the provision of extra food during pregnancy with very little support for women's mental health, stress and self-confidence.[27], [55]–[58] Hence, this could be an essential missing component of interventions to improve maternal motivation and uptake of health behaviors. Health research and programs should incorporate support for women to help them deal with negative feelings or emotions that may be triggered as they interact with intervention messages.

Intervention uptake and use in this study was also influenced by the caregiver's personal capabilities including knowledge, self-efficacy, decision making and time. Of note is that almost all women said they had the power to make child care decisions. This is different from the finding in our initial formative research [22] where we found out that women rarely had autonomy in decision making about child-care. One explanation could be that these women felt knowledgeable, they had someone they could go to with questions, who taught them in depth and who they viewed as a professional. Recalling that the VHWs were perceived to be competent and providing information that was reliable, this may have fostered confidence in the mothers' child care decisions and, as mentioned above, helped them feel adequately prepared to justify their decisions. Buchanan, 2004 [59] argued that health programs and

research should not only focus on the quantitative change in people's behaviors but rather their perceived improved ability to make decisions about their own behavior. Thus, understanding how to strengthen women's sense of autonomy and competence may be important in designing interventions that would more permanently change health behavior.

Strengths and limitations

The major strength of our study is that it provides an emic perspective of women who had interacted with child-care interventions over an extended period of time (~12 months) and, hence provides valuable insights on what, why and how interventions work at the household level. Usually research is undertaken from an etic perspective [60], which limits the understanding of caregiving behaviors and the cultural concepts that influence them. Often, when emic perspectives are explored, it is during the initial formative research over a short period of time. Peltó and Peltó [60] argue that emic perspectives are key in understanding caregiver behaviors and are essential to obtain an understanding of the emic frameworks for these behaviors. [38] In this study we see how important an emic perspective was to understand the whole caregiving experience.

This study had several limitations with respect to the generalizability of the findings. Women who were enrolled into the trial were part of an efficacy trial that provided most of the inputs to facilitate intervention uptake. Inputs included the provision of improved latrine, two handwashing stations, monthly supply of water treatment solution, handwashing soap from enrollment to 18 months post-partum and a SQLNS lipid from 6-18 months post-partum. This is very expensive and may not be sustainable. Thus, our results may not be readily generalizable to programs and interventions that do not provide these inputs.

Secondly, the interventions were delivered by well-trained and supported VHWs in one on one contacts in the participant's home. Although this type of counselling is highly effective [61], [62], it can also be expensive and unsustainable. Another limitation to consider is the possibility that "social desirability" played a role in the respondents' discussions. This is a general problem that we tried to minimize by indicating that we wanted to discuss their experiences and learn what they have experienced. Also, the interviewer was not part of the primary research team implementing the interventions to the women and visits were conducted separate from other trial activities.

Conclusion

Our study provides insights gathered from a small group of mothers. The intent was to examine their caregiving definition, expectations and experiences, as well as exploring how WASH and nutrition interventions interact with the caregiving environment to influence intervention uptake and childcare. Our study suggests that caregiving priorities and decisions are heavily influenced or driven by the interaction of mother's actions and the feedback that she gets from the child in terms of health and development. It also shows that community health workers are considered to be the most important source of child care information and hence, in this setting, the ideal person to deliver child care interventions. Based on the barriers and facilitators/motivators we identified, our results highlights the important of designing interventions on care-giving that include (1) high quality training of VHW that includes counseling, support and reminder materials (2) nurture as a psychological trigger for intervention uptake (3) a community-wide approach that addresses strong cultural norms and (4) quality one-on-one counselling that includes peer education and support. Our results also highlight that interventions and programs that aim to improve child care should also provide support for women to help them deal with negative emotions that may be triggered as they interact with interventions.

Table 4.2: Illustrative quotes from women on their understanding of caregiving

Theme	Illustrative quotes
Ability to feed, bath, do laundry, provide a clean and comfortable place	"One woman did ask what really child care was all about, so we did talk and share about it. I told them that child care is all about giving the baby good food, giving the baby a bath and washing the baby's laundry, making sure that the baby sleeps on a clean place and also that all the baby's needs are met and catered for. For instance, the baby might crawl and wants to sleep, the baby might end up sleeping on the floor and we might ignore the baby thinking that he is sleeping but this is not acceptable. If I see that my baby is sleeping on the floor, I take my baby and put him in a place where he can sleep comfortably." [020-21263-0-4]
Ability to adjust behavior based on child growth	The most important is to prepare food on time and wash laundry so that she is always clean and also that when she is hungry, I quickly respond and feed her. [020-61164-0-8] I first check the rate of her growth, I compare with other children of her age then I am able to see where I am going wrong or right that is how I decide to leave some things out. [020-61164-0-8]
Constantly checking on and the ability to correctly read baby cues	It is a huge responsibility; child care is one of the most difficult things to do. I must be constantly checking on the baby. I have to check whether the baby has been fed, the type of clothes he is putting on and his general health status, especially at this stage he is not able to speak yet so you have to be extra mindful, if he is sick you can tell by the way he is crying but at the same time it is confusing you cannot really tell whether he is crying because he is sick or it is common crying it takes time to tell what exactly will be going on. So, these are some of the things I face. [020-31740-0-5]
Patience in providing care and protecting the child Prioritizing child needs	Taking care of children requires a patient heart, when it comes to children there are difficulties and they do need a lot of care, this is what rushes to my mind. There are things that involve children whereby they might face dangerous incident things, so it is important to constantly and intensely keep an eye on the children. [020-31858-0-5] I think deeply about it, I want to do good things for my child, I do not want to see him cry or to be hungry all the time. I always make time for him even before I set to do any household chore [020-61300-0-0]

Table 4.3: Mother’s evaluation of their own caregiving competence and illustrative quotes#

Caregiving Score	Theme*	Illustrative quotes
Five (65%)	Child not sickly	I am satisfied with the way I am taking care of my child. My child is not a sickly child he hardly falls sick, even with this body I can tell he is fit, and his weight is weightier as compared to other children who are older than him. [020-31740-0-5]
	Child healthy and able to play	I am good; my children are in good health I am sure you can see that for yourself they are running around. I am the best; my children are running around, they are never sick and are strong they just run around. [020-51283-0-9]
	Not facing any problems with child health	I have not faced any problems for instance my child has not suffered from stomach pains. I have never given him medication for any stomach problems. To add on my child does not eat soil or chicken waste he does not like to see chicken waste. If he is to step on chicken waste, he cries out a lot because he has just started walking. He also knows that he must wash his hands before eating and when he eats rice, he does not use his bare hands he requests for a spoon. He also knows that he must sit on a clean place if he sees that the place is wet, he moves and shows you where it is wet, he likes to sit in a nice place. So, I place myself at the top because I am the best care giver to my child. He is in good health if he catches a cold it is because at times when I am not around, he gets to play in the rain with his brother, but he only catches a cold maybe after each every 3 to 4 months most of the time he is in perfect health. [020 32026-0-3]
	Child having an understanding of perceived good behavior	
	Feedback from neighbors	I have also heard my neighbors saying that when it comes to feeding my child, I am an expert because they see that my child is very healthy. I feel more encouraged that I am good at feeding my child. [020-20949-0-4]
Four (30%)	Prioritizing child needs even with limited resources or time	Everything he needs even when he cries for something and I do not have money to buy it I make sure I buy it on credit at the shops. If he cries, I even carry him on my back and when I am tilling the fields, I can leave all that work to attend to him and come back home. I love [INDEX CHILD] so much. I make sure the place he sleeps is also good for him and wash his blankets so that they remain clean including his clothes and also his food whatever he feels like eating at that particular time that is what I give him [020-51131-0-1]
	Inability to provide perceived “good” things for child	I always make sure my baby is clean and prepare food for her. I try my best to cook but at times it looks like it is not working at all. I get to see other mothers doing certain things for their children but at home I do not have those things and it will be my desire to provide those things for example some mothers can

Caregiving Score	Theme*	Illustrative quotes
	Failure to achieve perceived good behaviors	afford to buy potatoes for their children, yet I cannot afford that. I end up preparing the food that I can afford at that time. [020-61164-0-8]
	Time constraints affecting caregiving	What makes me place myself on the fourth step is that my children's health and their capacity of reasoning are way different as compared to other children of their ages in the community. There are a few things that I am still a bit behind especially the issue of eating soil I am still failing to control him. [020-31914-0-8]
	Inability to prioritize child needs among competing priorities	And also, like I said before when I did go to the garden, I did not have time to feed the baby so it means I have failed, so this is where I place myself. [020-51291-0-8]
	Not taking up intervention lessons	...there are things that I am not doing when taking care of him. Especially when it comes to food and the time to give him a bath that is where I am still running short. I might be late in preparing his food for instance I plan to prepare his food at 9 and I end up preparing it at 10 I think that is where the shortcoming is. I might come in very late from wherever I am coming from or maybe from the garden so the time to prepare food and warm up his water to bath there isn't enough time to that because at times I am by myself so again this is where another shortcoming is. [020-51216-0-5]
Three (5%)	Inability to provide desired food for child	The ways I was taught to take care of my baby some I did not use but as of now I am trying to meet the baby's needs, because of some of the things I did not do in taking care of my baby, so I deserve to be on the fourth step. [020-51206-0-4]
Two€ (0%)	Failure to feed or do laundry for the child	I cannot afford to do other things. For instance, the food my baby ought to be eating at times I may not find it. For example, milk to put in tea I may not afford it, so the baby ends up having black tea. So, I cannot claim to be an expert or best care giver. If I can get everything and take care of the baby and feeding the baby on time and give everything, she needs then I can qualify to place myself at the top. [020-51180-0-5]
One (0%)	Laziness, poor planning, inability to provide perceived good food.	This mother might be failing to feed the baby well and having no time to do the baby's laundry, so you end up at the bottom step. [020-51219-0-8]
		It is one of those very lazy mothers because care giving to your own child it's not only about money to buy food for the child, but one can actually grow their own vegetables and feed the whole family, some mothers they actually fail to feed their babies with a decent relish, and they end up giving them soup instead. As of me I am a very hard working mother I always plan my things ahead of time I make sure I wake early in the morning and do my household chores and also prepare some porridge for my baby and before I milk the cows I prepare my garden so that I get food from there to feed my baby with a decent meal. For my child to have the best I have to work as a parent. It is pure laziness if one is serving their

**Caregiving Theme*
Score**

Illustrative quotes

Missing child
immunizations

children sadza without any relish and also poor planning or having no plans is another reason for all this. We must always find something to do it is better to have no food because you have to buy it from the shops but food that we can cultivate ourselves things like pumpkins, green vegetables, cassava these we can grow, so we must get to work, and do it and it does not need money. [020-61163-0-7]

She is type of a mother who does not get her child immunized on time, she is always procrastinating to go and at times skips some of the injections that her child ought to receive. So what they are doing at the clinic is that if you miss an injection they will give your child two injections at the same time, the one you missed and the one for that date, so that type of a mother is not a good mother at all. [020-61300-0-0]

Women ranked themselves on a scale 1-5, with 5 being the most competent mother and 1 being the least competent

* Mother's at all levels gave similar reasons for ranking themselves highly, hence these are highlighted only for the highest rank and for lower ranks only themes around why women did not rank themselves highly are shown.

€ No women ranked themselves on these ranks but expressed who should be ranked on the lowest

Table 4.4: Illustrative quotes from women about important sources of caregiving knowledge

Theme	Illustrative quotes
VHWs trained	They (VHWs) are trained for this kind of work and they have in depth information. [020-51081-0-5]
Not having problems with VHW lessons	I did not face many problems through what the village health worker taught me. [020-21238-0-9]
VHWs have in-depth information	It is because that they (VHWs) have more in- depth information about children. [020-21238-0-9]
Child care is the primary job for VHWs and clinic staff	I did get information from others but with village health worker that was her main aim when she came to teach it was to give me this information only. It is with the clinic too we got time to receive lessons that were to do with child care only. So, it is different with others who gave me haphazard information hence it was never the same as the time that I was given by the village health worker. [020-51102-0-9]
Mother's information perceived as back dated	My mother's information is now back dated, and I get to visit the clinic when I need my children to get immunized. As for the SHINE health workers and village health workers they did have specific dates that they visited so I did get most of the information from the village health workers and SHINE health workers and our local village health worker. They always come and the information from the clinic I only get it when I do go there to get my children immunized. If there are no injections to be received, I will be at home with my children, but the village health workers do visit us in our homes, and we sit down and talk about 3 hours and they will be teaching me but at the clinic they do not have that time to talk. They get to talk to us for a few minutes and if I am able to listen then that's good but if I miss it then I would have missed out. As for the village health worker we do get to rewind our lessons and have a recap of the last lessons so that they can see if I still remember the lesson received, we then carry on to the next lesson and so forth. [020-51283-0-9]
Clinic visits are for specific reason and lessons are rushed	
VHWs visit at home and provide in-depth information and review lessons	
Clinic staff do not have enough time and lessons are rushed	It is the village health worker because he taught in depth information and he did give me time to ask. At the clinic they do teach us but because they will be rushing to do their work as nurses, they do not give us time to ask them questions. The village health worker does teach me as an individual I quickly grasp the lessons and I get to ask questions. [020-61145-0-7]

Table 4.5: Illustrative quotes about facilitators to initial intervention uptake and sustained use.

Theme	Sub theme	Illustrative quotes
VHW communication		Intervention delivery agent
	Appreciated VHW way of teaching	“I chose to use the lessons because of the way she [VHW] taught. I told myself that I want to try my best to use these lessons and see the results, but I did discover that it does help me.” [020-21263-0-4]
	VHW way of teaching was new	“It was new because I have never been taught in this way. I used to breastfeed just for the sake of breastfeeding so in the way I was taught the child is to breastfeed exclusively for the first 6 months without giving anything. It was in the way she handled us, she did ask me questions and taught in patient way. She did ask me if there were things that I did not understand, and she allowed me to ask her questions particularly in the area that I did not understand. I have a heart that loves to ask questions and she did read to me time and again on anything I did ask.” [020-20949-0-4]
	Patient and respectful of women’s time	I was satisfied because I did not have any problems with her; she did her things in a free manner. She did ask whether I had work to be done if there was a time, I was not busy that is time she did suggest she would come. If I was busy, she did proceed and go somewhere else and when I was free, she did come and sit down with me and she did not force to do the lessons. She was a very free person if she was not a free person maybe I could have refused to take up the lessons. She was patient person even when she did not find me at home, she did come back time and again. [020-51060-0-2]
	VHWs were polite	If she was teaching and I did not understand the lesson I would ask her to repeat and she did answer back, and she did not answer in a rude/impolite manner. [020-320126-0-3]
Patient and allowed for questions	He took his time and he would talk with me each lesson at a time and he did explain and would ask me the things that I would have grasped then. [020-21326-0-4] If there is anything, I did not understand she did explain it very well until I understood, she did not just give the lessons as it is, she did explain the lessons. I would ask her why some things were the way they were she did explain again and give reasons and I quickly understood it. I remember asking her why children are not to be given oil or medicine for Colic because all the years we been doing this and even the village health worker I am sure she once used it back then on her own children but she told me it was because of ignorance back in the days but because in the present day we now have this knowledge she encouraged to use it and see whether there were	

Theme	Sub theme	Illustrative quotes
		any challenges.....I did use the lessons and saw it for myself that it was the truth. [020-31914-0-8]
	Allowed women to continue with other chores while receiving lessons	She was a person who took her time, when she was teaching, she did allow me to do other things for instance she would not ask me to come and sit down while being the lessons, she could teach while I did my laundry or doing my dishes. [020-51206-0-4]
	Overall approach	“The way she announces her arrival and her approach made enjoy listening to her lessons.” [020-51177-0-8]
VHW knowledge	Perceived as professionals	I thought him being a village health worker it was something I had to use. He is professional therefore if he tells me something, I am should to use it. [020-51219-0-8]
	Perceived as having necessary training	They are trained for this kind of work and they have in depth information. [020-51081-0-5]
	Messages did not cause problems	I did not face many problems through what the village health worker taught me. [020-21238-0-9]
	Used reference books	I did not know much about health issues and she had the knowledge, she also referred to her books it was not something she would teach from her head. So, this is what made me really receive everything she was teaching me. She would leave some of her own personal work to come and teach us, so it was something that I accepted easily. [020-31862-0-1]
VHW reliability	Showed up for all scheduled visits	“If the village health worker did make an appointment with me, she would always come so that made me be satisfied with her.” [Interview 7]
	Started and finished lessons on time	I was satisfied because she kept her time, if she said we are starting our lessons at appointed time and end at yet another appointed time she did follow that [020-32108-0-4]
		Intervention message
Mode of delivery	One on one made it easier to ask questions	It is different when we are a class, I might be shy to ask questions after being taught because my others fellow colleagues may laugh at me but if it is the two of us with the village health worker, I feel free to ask him questions and he does explain to me. [020-61145-0-7]
	Use of pictures, charts and games	He did bring his books and some pictures drawn in them, picture of plates clean ones and dirty ones and he did ask me to choose the good and the bad. There were also pictures of a healthy and unhealthy baby or a baby with mud and one sitting on a play mat also another picture of baby playing inside the play pen. There is a game he did bring that had a ‘snake’ on it and we did play that game. He had a lot of pictures and he once brought some balls and he did go around

Theme	Sub theme	Illustrative quotes
		the yard placing the balls on every dirt he saw like chicken waste which was not allowed. [020-21326-0-4]
		We the elderly we learn by using pictures, so it is different being taught my words. If I did forget I would remember the picture. He did give us a chart on how to breastfeed the child and I did count numbers from 1 to 12 which are times I ought to breastfeed the child. At a certain age the child must drink milk maybe approximately 8 times so I would go back and read that chart and I would know how many times I need to breastfeed the child and that it is time for the child to have more of the porridge. At certain age the child must drink breast milk maybe 4 times a day and that I must be mixing the porridge with other foods, so those pictures did help me a lot. [020-61145-0-7]
	Adequately explained	She had books with her after explaining the lesson that day she did read about the lesson and she did show me pictures, so it made me quickly understand for instance the way you hold the baby when breast feeding. When I looked at the pictures and I got to see the way it is done, she also brought food charts which she did put up. [020-21230-0-9] At times she did explain to a point whereby I could understand it myself I would just accept it for it was simple and straightforward and it was very clear. [020-51283-0-9]
	Use of demonstrations	She did actually demonstrate by preparing the porridge until it was the correct consistence which was to be thick, and she did put other foods if they were available. So, she did demonstrate for me to see. [020-51291-0-8]
Ease of message	Easy to use	It is because she came and taught me and I felt it easy to use everything she taught me. [020-21238-0-9]
	Easy to understand	Most of the lessons were easy to understand [020-31777-1-5]
	Easier with familiarity	It was difficult at some point, but as I got used to it and was in full swing of the program it became easy to use the lessons. [020-201949-0-4]
	Intervention messages are common knowledge	It is something that is not difficult to do because it is common knowledge to everyone that one must wash their hands after using the toilet and that unsafe water needs to be treated so there are things that can easily happen, it is not difficult to do if one is not lazy. [020-32026-0-3]
Duration of lesson	Wanted more time	Time did always run short because she did explain thoroughly during the discussion that all I wanted was to learn some more lessons and ask more questions and at times she had to push our discussion to the next visit. [020-31914-0-8]

Theme	Sub theme	Illustrative quotes
	Did not mind long lessons because of the knowledge gained	<p>If you are one person who is eager to learn about the program then time is not any issue, at some point there is not enough time because I happy about the program and still interested to learn more. [020-31836-0-1]</p> <p>The time he (VHW) took was fine with me. Even if it was too long it was for my own benefit because I was gaining knowledge to know how to take care of my child, so it was fine with me. [020-31740-0-5]</p>
	Duration was adequate	<p>It (time) was fine with me because everything she did with me was worthwhile I could have seen it as something of no importance yet it was of value; especially this season we are in whereby we are having houseflies infesting our homes and the village health workers do encourage us if the house fly are to fly over your food and maybe you will be coming from the bush and you touch food without washing your hands.... She taught me very important things that important in this life. In our custom we thought that washing our hands with water only was enough to make our hands clean. [020-51124-0-3]</p> <p>it was adequate and she left on time so that she could carry on with other work and at the same I would have understood all the lessons taught.</p>
	Lesson duration was ok because it was scheduled	<p>It was fine he would usually give me the dates he would come and visit. So, I would plan my activities for the day or the day of visit and make sure I did leave time to receive lessons from the village health worker. So, planning ahead made me have time for the lessons. [020-61163-0-7]</p>
	Time commitment did not disrupt other chores	<p>It was fine and it never interrupted with my daily activities. [Interview 7]</p>
Child feedback	Fear of harmful situations	<p style="text-align: center;">Caregiving environment</p> <p>“I did use all the lessons because I did realize that the lessons were working for the good, so I thought that if I am not to use these lessons I might end up in a harmful situation. Therefore, I decided to use the lessons because it was something good.” [020-21263-0-6]</p>
	Developmental benefits for the child	<p>“[INDEX CHILD] is a clever baby; if I am to send him to fetch firewood, he gets the firewood and gives to me or to fetch firewood to put in the fire he does that. As of now if I am to send him to get a ball or chase the chickens away, he does chase them away. Some of my children were not so clever I could not tell really whether they were imprudent or whether they were clever I could tell the difference they were average. So, I did realize that all the lessons received did help him to be a smart baby. Right now, when my phone does ring, he cries for it so that he can talk</p>

Theme	Sub theme	Illustrative quotes
	<p>Baby perceived healthier than previous children</p> <p>Perceived better overall growth rate compared to previous children</p>	<p>on the phone. The phone did ring again, and I told them to wait because the baby was crying because he wanted the phone, so they had to put a text message through for me to know that you were coming. All my children before this one never asked to answer the phone but if I am to give it to my baby, he is able to talk on the phone, so this is something he is doing because of the lessons received that I also used.” [020-21262-0-4]</p> <p>“My first child when growing his health status was not all that good but this baby now, she is much healthier, and she did other things earlier than expected? Talking, to be able to recognize objects like cups, plates, pots, sweeping broom so she knows all these things.” [020-21397-0-2]</p> <p>“I saw that it was good for my baby’s health because her growth rate is different from the rest of the children I had before her. Most of the time I gave my previous baby porridge at the age of 3 months and this baby I have now I gave her at the age of 6 months, so I saw that there was a difference, her bone structure was from the previous baby. The previous baby was not healthy yet the recent one was much healthier. The baby is not weak, and you cannot tell whether she is sick or not, you cannot really pick what is wrong with the baby. I never experienced any health problems with my recent baby.” [020-21397-0-2]</p>
Family support	<p>Family first opposed but once they saw results on the baby supported use of interventions</p> <p>Family provided practical support e.g. reminding and helping with child care activity</p>	<p>“When told her at first, she did oppose it and I did tell her to wait and see the results on the baby I had now, so she did not oppose it that much anymore. So, she did allow me to do it though she insisted they had their own way of doing it back then but she does not entirely oppose it anymore she just watches and see the results. She did appreciate it as a good thing though because it protects the baby from many diseases and does not susceptible to diseases.” [020-21263-0-4]</p> <p>“I do not usually forget because my family reminds me. At times after using the toilet I would forget to wash my hands and they would remind and ask me why I have not washed my hands, yet I am about to breast feed the baby after visiting the toilet” [020-21326-0-4]</p> <p>“It is something that they did appreciate, while I was not home, I did find the baby put inside the play yard already.” [020-51101-0-9]</p>
	<p>Family provided emotional support such</p>	<p>“By then I was staying with my sister in law who is not part of the SHINE Program she did like it and if the water got finished she did remind the village health worker that we no longer had Water Guard and the village health worker did bring it and she would ask me why I did not</p>

Theme	Sub theme	Illustrative quotes
	as encouraging and motivating	<p>report to her that the Water Guard had been used up, rather to hear it from my sister in law.” [020-51206-0-4]</p> <p>Those I live with they were all satisfied about it because my grandmother has always encouraged me to practice hygienic methods, which the baby must be taken good care of and not to be careless and put the baby anywhere. She did applaud the program because it encourages hygienic practices. When toilets were built, and the tip tap containers were put in place she was the first to rush and use it, so she did value it because it was something good. [020-51102-0-9]</p>
Husband support	Remind and also help with interventions	He [Husband] helps in times when I forget he can remind me, or he does what need to be done.” [020-51060-0-2]
	Attending lessons	There is time when the village health worker visited us, she did teach us while we were together with my husband. [020-31914-0-8]
	Making resources available	He (Husband) saw it has something good because when he gets money he brings [INDEX CHILD] eggs and I boil them and give the eggs to the baby and he also brings peanut butter to put in the porridge. [020-51124-0-3]
	Encouraged women to attend and use lessons	I did not have problems with her [mother-in-law] she did encourage me to use the lessons received, including my husband he would call me on the mobile phone if the village health worker came looking for me”
		He did say at that time he did not have any money when the toilets were being built which was something to do with hygiene so he kept encouraging us that since they are bringing in things to do with hygiene we must also continue to be very hygienic people that is when I realized that my husband loves being clean it is only that at times we cannot afford to have those things we need. [020 51184-0-9]
	Supported because of perceived benefits	<p>On all the lessons that I received as something I loved to do, he (husband) did encourage me to use the lessons, listen and do it for instance with family planning I never used The Pill but I realized later on that it was something right to use. [020-51081-0-5]</p> <p>Everything was good for him (husband) because he could see the baby was more intelligent as compared to other babies of his age who are raised differently from the way we did it, he is</p>

Theme	Sub theme	Illustrative quotes
Social support	Discussions with other study participants	<p>intelligent and in addition the baby was not sick that often we did not face that problem. [020-51102-0-9]</p> <p>There is certain lady I talk to when she visits me at my house, we do discuss about it because she was the first one to join the SHINE Program before I did. We did discuss about the negatives and positives of receiving the lessons. [020-51283-0-9]</p> <p>When I was with my friend I did comment and encouraged one another about how good the lessons are and that we must use them. [020-51136-0-6]</p> <p>I told her about the lessons I had received from our village health worker and she also concurred that she had received the same lessons from our village health worker. She was in agreement with the lessons she received, we did discuss about the same questions we were asked, it was something we were both in agreement with. [020-31671-0-8]</p>
	Help from neighbors	<p>Here at home my mother in law also does assist about issues to do with child care and teaches in the way I should handle the baby, so all of them they do help me including my neighbors do help me. [020-21263-0-4]</p>
Disease prevention	Reducing risk of diseases	<p>“I did use these lessons because I saw that it reduced a greater risk of contracting diseases by the baby.” [020-32108-0-4]</p> <p>“I think it is something good because I did give my children milk and food way before they are 6 months old but they did have stomach problems we were always by the clinic because Diarrhea, so as of now I can see there is a difference my recent baby did not have not have Diarrhea that often as compared to my previous children there is a change.” [020-51291-0-8]</p>
Social status/social affiliation	Other women doing it	<p>She taught me lessons that I saw other women were already doing. [020-61164-0-8]</p>
	Positive feedback from neighbors	<p>We have to share the information amongst ourselves, at times you hear other women appreciating how beautiful and clean my baby is, I tell them it is because of the lessons I received from the village health workers. So, in that way they are able to copy and do the same by sharing with them the information on child care so that their children may also be good looking and presentable and that their children are not disgusting when people see them. [020-31740-0-5]</p>

Theme	Sub theme	Illustrative quotes
	Child perceived as doing better than other children	Comparing my [INDEX CHILD] with other children who are in the same SHINE program with him, [INDEX CHILD] looks much healthier and the others look sickly. There are some children being fed with porridge from donors but comparing them with [INDEX CHILD] who is not taking that same porridge he is much healthier as compared to them. [020-31777-1-5]
	Other women wanting to emulate behaviors	<p>Yes, there are. I am a better mother because while visiting others or in social meetings I can actually see that my child and myself are way better when I compare with others in terms of hygiene, I usually like things that are smart it is only that I do not have much, but I like smart things. [020-51184-0-84]</p> <p>“She [neighbor] really esteemed it and she would ask for the Water Guard and some people were coming in to ask from me because during the dry season most people get their water from the spring and unprotected wells, so I was protected because I had 3 tins of Water Guard. My visitors would happily drink my water knowing that it was safe. I would put my water chat on the container so everyone would see that my water was protected, and that chart would remind me every morning to prepare my water and protect it.” [020-61163-0-7]</p>
	Perceived better household environment	<p>It is something that makes me happy because it is something people are commending and ask me how I go about it; hence I am doing something good which others find it difficult to do. [020-51060-0-2]</p> <p>“At times when I am sitting at home and compared my homestead and that of my neighbor and they see that they are different. It is something that makes me happy because it is something people are commending and ask me how I go about it; hence I am doing something good which others find it difficult to do.” [020-51060-0-2]</p>
	Fear of shame	As the mother, I am the one who is always with the child so if I do not feed him properly, he likely to develop Kwashiorkor and it will be such a shameful thing in the community to have a child with Kwashiorkor. [020-31740-0-5]
	Compliments from neighbors	When they visit, they go to the toilet and compliment how clean it looks and washing of hands when they come out. They say SHINE is good because at their homes they just come out of the toilet without washing their hands and start touching food so here by my house they can use the toilet and at the same time wash their hands without having to look for water, so they really admire it. [Interview 7]

Theme	Sub theme	Illustrative quotes
	Intervention messages built on common practice	We were taught that when washing hands, we must use running water but here you find they are still using water dish to wash hands and the dirt still goes back into the same dish and they keep rotating their hands in that same water with dirt, though the hands might look clean but there are not as clean. Furthermore, they do not use soap to wash hands because at times the soap is not easy to get. [020-3194-0-8]
Availability of resources	Inputs provided through the study	“I am happy because I now have somewhere to wash my hands, at times I did forget to wash my hands and it was too much work to have to put water in the bucket and wash my hands I would remember later on that I did not wash my hands. So, having the toilets built for us there is place to wash our hands the moment I come out I am already washing my hands and I go home with my hands clean” [020-20949-0-4]
	Money from farming used for child care	I am grateful for all the assistance they gave us for instance soap to wash our hands it is something that encouraged us to continue to use hygienic practices. [020-51102-0-9] If I do cultivate some tomatoes in my garden and sell the tomatoes, I get money to buy things for myself and my child and other things I need in my house, this is what I am able to do. [020-51184-0-9]
	Food available from family plot	Yes, I felt that I had he means though I did not have; the moment she left I did find foods like vegetables though most of the vegetables are rotting because of the rains now but we do plant some in our gardens. Chickens we do rear our own and we also houseplant potatoes or I can buy so that I can give my baby hence it was not too difficult for me. [020-21263-0-4]
	Adopting behavior prevents diseases and save money for medical bills	The good thing he (husband) saw is his child never getting sick and going to the clinic to receive treatment. Having to get the child treated calls for time and lots of money to travel and to pay the medical bills so he saw his child growing up without being sick my child visited the clinic to get his immunization injections, so he saw this as a good thing. [020-31914-0-8]
Knowledge		Maternal capabilities
	Getting new knowledge	They gave me a lot of information and I was enlightened indeed because some of the things were not there yet when I had my previous child. Back then I was taught just after child birth if a child cries, we feed the child with porridge and to give sweet foods, but they do not encourage me to do that. They taught me sour porridge and porridge with peanut is good for the child not to give him sweets and corn snacks. Remember the snakes and ladders game if your child gets bitten by the snake it meant you were feeding your child with sweet and partially uncooked foods, so it taught me a lot. [020-51177-0-1]

Theme	Sub theme	Illustrative quotes
		They taught us about good ways of feeding our children that I was not aware of for instance mixing porridge with vegetables and eggs to add more nutrients to the diet, I was not aware of this all. [020-20949-0-4]
		I was not aware that I must constantly check the place where my baby is playing. I thought that if the baby is slightly older, I can leave them to play by themselves, but I did realize the importance of being mindful of the baby when he is playing always checking the place he is playing on and that the baby must not eat soil or chicken waste. I thought that it was just soil it was unimportant because the elders did say it was healthy to eat the soil, but it must not be so for a baby to play with soil. [020-51102-0-9]
	Knowing what to do	So, I was able to know the type of foods I ought to feed my baby with, through those pictures I saw. [020-21238-0-9]
	Lesson added to prior knowledge	About hand washing I knew I must wash my hands but not with soap. I did see that washing my hands with soap there is more dirt removed water without soap does not remove all dirt so that was important [020-31858-0-5]
Self-efficacy	Did not see deterrents in taking lessons	I did not see anything that could deter me in using the lessons. Everything was fine because nothing was needed such as money to use those lessons the food that is required it is something that we have already been eating and thus I give that to the baby. [020-21326-0-4]
	Felt capable of taking up lessons	I felt that I was capable to use all the lessons received I had the desire to do it whether I liked it or not I just had to commit myself. [020-51124-0-3]
Decision making autonomy	Power to make infant feeding decisions	I feel I have that power depending with how much money I have at that particular time. [020-31914-0-8]
	Feel adequately informed to make child care decision	I feel I do have that power because of the information I received it helped me. I am no longer at a stage where I can be told what to do when it comes to my child, I am content with SHINE. [020-51177-0-1]
	Mother is the best person to make child care decisions.	It is my right to choose the type of foods my child should eat. Who else can do that besides me the mother? I make the time table when she should eat porridge even if we are to cook later on, I know my child would have been already fed. [020-31836-0-1]
	Listen to but do not use advise from key family members	I did that when I used to give my children traditional medicine when I joined the SHINE Program I changed. That information from the grandfathers and grandmothers they tell me I do listen to them, but I do not use it; it is not a crime though I listen because I am married to their son, but I have since cancelled giving my children any form of traditional medicine. My father in law did

Theme	Sub theme	Illustrative quotes
		talk about it as well unfortunately he did pass on. He is the one I was telling you about he did bring traditional herbs I did take them but did not use them because of the new information I had acquired I considered the traditional herbs as something they did in their own days so I did not use them. [020-51283-0-9]

Table 4.6: Illustrative quotes from women about barriers to intervention uptake and sustained use

Theme	Sub theme	Illustrative quotes
		Intervention delivery agent
VHW reliability	VHWs not coming for lessons	She (VHW) did take long time without paying me a visit and after the delivery of my baby she took about 4 to 5 months without receiving any lessons from her so her visits were all not that good because workers from SHINE did come and would ask me things some which I was not aware of because I had not received any lessons. Her visits were not consistent. [020-31858-0-5]
	VHW not delivering study inputs on time	but what hurt me is that we did not receive soap every month, he (VHW) would skip another month without giving me any soap but I will be in need of that soap to wash our hands so that did upset me. [020-51184-0-9]
		Caregiving environment
Lack of family support	Disagreements with intervention messages	“I did talk to family members including on my husband’s side and those from maternal family. However, they did oppose me, and they said I was going crazy because of SHINE. I did try to explain to others, but they did not want to hear anything about SHINE. I tried to explain to them about Anterior Fontanel and tell them that there is nothing like that. It is only that when the child is born its head is in two parts because it will be impossible for a mother to give birth to a child whose head is fully intact. They did continue to say that the SHINE Program is going to affect the children in bad way. My own mother did discredit the program she could not accept that a child can be born and not receive medication for Anterior Fontanel. I kept enlightening them that if a child is to be born with its head bones (skull) strong that person would not be able to give birth to that child, the gap between the head what they term as the Anterior Fontanel is there in order for the mother to give birth without much pain it compresses but there is nothing like treating Anterior Fontanel. Some did understand it, but some did not agree for they wanted to see the outcome.” [020-61145-0-7]

Theme	Sub theme	Illustrative quotes
Lack of husband support	Family not willing to adopt lessons	<p>“They hated it [Play yard] because they said it frustrate the child. They said the child needed to play than being inside a cage; she needed to crawl, so they hated it.....I was very stubborn about it and pretend as if I am not hearing them.” [020-61145-0-7]</p> <p>For instance, in some homes if you are to give the baby food before the stipulated time, some will be suggesting that I give the baby food while the village health workers forbid that, so some might end taking the suggestion of those they are staying with since they are together. [020-51180-0-5]</p> <p>The problem I faced is, here by my house my family members do not like water with Water Guard put in it, they were not used to it. This was the biggest problem until now I still have the Water Guard the buckets do not have water. This is the biggest problem during the first days it did work but it was a huge problem. We would only drink it after a long period of time. So, it a big problem, so I end up not putting water guard in the water. [Interview 7]</p>
Lack of social support	<p>Not making resources available for child care</p> <p>Neighbors perceived the lessons a waste of time</p> <p>Disagreements with intervention messages</p>	<p>It is a challenge because I am not employed, and my husband is the only one who works when he gets paid, he spends his money has we wishes. So, when I get a chance to work, I spend all my on [INDEX CHILD] which is something that me and husband quarrel a lot. [020-31777-1-5]</p> <p>They did say these people were wasting our time instead I should be attending to my fields and they would go on to say we will be just sitting talking for more than an hour instead of doing something more sensible as in tending my fields. That is how some of us are created there is nothing we can do about it. [020-51283-0-9]</p> <p>I once spoke to other women who are not part of the SHINE Program, they did scorn me and they spoke ill of the program, and they did not accept that a baby must not eat soil or chicken waste because they themselves grew up eating those things and they said I was being pretentious about being a hygienic person. Instead I did teach and told them about the importance for instance feeding the baby with solid foods before they are six months, some at three are already giving their babies porridge. So, I told them about the challenges they were going to face like the baby having diarrhea and that is what they were experiencing yet I was not experiencing that. My baby only had a fever when his teeth were coming out or have a cold, so I saw that there were some differences. Some do purport that their babies having diarrhea is a result of their teeth coming out, yet it is the mothers’ not taking good care of the baby. [020-51102-0-9]</p> <p>Yes, they do talk about it but they discredit the way I feed my child especially to exclusively breast feed for 6 months, they say it is not good for the baby and that I must give the child solid foods before the 6 months for it is not good for the development of the baby. They believe that their tribe</p>

Theme	Sub theme	Illustrative quotes
		must eat food and that the child must eat first before the mother meaning just after giving birth to the child I the mother must not eat before the child it must eat first. [020-61145-0-7]
	Neighbors expressing negative sentiments about the intervention messages and the program	Some did accept it while others did despise it, those who are not part of it they do despise it they did scorn me why I was not feeding my baby with solid foods and said it was something useless because the SHINE people are bothersome. They did ask our where our blood was being taken to. My neighbors do talk up to a point where one might decide to drop out of the program but knowing my aim I did not drop out. [020-51291-0-8]
Lack of resources	Not enough money	Money is not enough, the little amount I have I use it to buy things that I can get from that little amount. At times I do desire if I could get certain things for my baby, but the money always make me fall short, but I do desire to buy things for my baby. [020-31858-0-5]
		I wish I had money I would buy fish, eggs for baby, like they taught us before I can give the baby an egg that is boiled a day to help with the development of his brain and at times beans, fish or meat I do not get them every time hence my desire to do something so that I can use the lessons that I was taught so that it gives good health to my baby. [020-51124-0-3]
	Lack of food	I am failing to give him eggs and other foods I must be providing for him [020-31914-0-8]
		Yes, he did teach on that but at times I do not have those types of foods so there is nothing I could do I did work with what I had. [020-51184-0-9]
		It can be difficult in that after being taught for instance we must give our children food with enough nutrients and so I began to ponder where I could possibly get the food so already, I am making it difficult I must try to use and have the love of doing for my baby and try and find those things for the baby. If one is to think too much about how they will get the food, it actually makes the whole thing difficult. [020-51291-0-8]
	Study inputs not delivered on time	I was not really satisfied with the issue of hand washing they did say it is important to wash hands using soap but I would go for a month or two months without receiving any soap because it has not been delivered, so what help did it do when I only washed my hands using only water so this is one thing I was not satisfied with. [020-31858-0-5]

Intervention messages

Theme	Sub theme	Illustrative quotes
Intervention complexity	Baby age made intervention difficult	At times I cannot say I was successful enough, as a baby who is now playing and running around alone, he might do anything. [020-51081-0-5]
	Baby refusing to eat	During the first days I did put the butter in porridge I really do not know what will be happening with him and he would refuse to eat the porridge so I did try to put the butter in butternuts and he would eat a bit and leave it but at the end he ended up enjoying it that he did it until he was full. [020-51124-0-3]
Forgetting		Maternal capabilities
		I am happy because I now have somewhere to wash my hands, at times I did forget to wash my hands and it was too much work to have to put water in the bucket and wash my hands I would remember later on that I did not wash my hands. So, having the toilets built for us there is placed to wash our hands the moment I come out I am already washing my hands and I go home with my hands clean [020-20949-0-4]
		I was prone to forget other things as something that I was not accustomed to yet [020-51206-0-4]
Time	Not having enough time	“I did manage to use all of them but at time especially sometime back I could not find time to thoroughly clean my yard even until now I fail to get time to do it. I love to do it but because of the rains I fail to do it. So, it is cleaning the yard and washing my baby’s hands I was taught all of this and I also realized the importance of doing it.” [020-51081-0-5]
	Balancing work and child care	“I am into mining, a gold panner, so when I had a baby, I had to take leave of that type of work because it is very tough work to do. Again, this sort of work does not give enough time to prepare food and bath the baby on the time and also to see how the baby has been faring all day. So, if I am to go to work all day the baby cries a lot because I am not there and yet we are taught that babies should not cry for it disturbs the baby.” [020-31914-0-8]
	Balancing other household chores and child care	Yes, at times I was able to use the lessons but things like sweeping I did it once in a while because I had to go to work. [020-21238-0-9] “Time to do some chores when the village health worker did visit became impossible.” [020-31914-0-8]

Theme	Sub theme	Illustrative quotes
	Travel outside the study area	I did not get the chance to use all of the lessons because we did move houses thereafter the village health worker did not come and visit us. [020-32108-0-4]

Table 4.7: Illustrative quotes on mother’s feelings about not being able to adopt or continue using interventions

Theme	Illustrative quotes
Extremely painful	<p>It did hurt so much because it is better for a person to suffer without the knowledge. It hurts so much to fail to do something knowing the good benefits of doing it, it hurts.” [020 31914-0-8]</p> <p>There are other foods with necessary nutrients to build her body that I cannot afford so I see it has not the best way because there are certain nutrients I am depriving her of and when I look at her I desire to give her those foods, there are actually a lot of food I am not providing for her it hurts so much. [020-31671-0-8]</p> <p>It hurts in my heart and I wish that when I do get money, I have to buy my child this kind of food, for instances potatoes at least my child will get to have a variety of food. It is porridge with milk or porridge with cooking oil it becomes monotonous. I desire that the moment I get money I will buy those things. [020-20949-0-4]</p> <p>It hurts in my heart desiring that if only I get something so that my baby gets all the sufficient things he needs; so, if it is vegetables everyday my heart aches, I prefer to look for something just for him only like kapenta fish so that it does not become monotonous I can alternate vegetables and kapenta fish. [020-51291-0-8]</p>
Perceived as affecting physical health Triggers actions and feelings of helplessness	<p>It hurts me so much to the last degree at some point I can lose weight so much that people may begin to wonder why I am losing so much weight. I might lose weight over this, that my baby is not getting enough food. [020-21263-0-4]</p> <p>I am hurt but there is nothing I can do because I do not have the money.” [020-31671-0-8]</p> <p>I was so used to getting soap and Water Guard every month end including air time but now it becomes a very big concern especially the first two months of being weaned off the program I became so stressed. The last time the village health workers visited me I asked whether I had been weaned off the program and they said yes, it had come to an end and I was content with that because I cannot force the program to go when its time lapsed. It is such a burden for me even the well we are using I am not really comfortable, though I had two bottles left I had to pour all the contents of Water Guard into my protected well though I knew it was of no help because there was just too much water. I am not really happy about it though I am doing it; it is not in me to do this. [020-61163-0-7]</p> <p>I think that if I am to die how are my children going to survive and in whose care am, I going to leave them in. [020-20949-0-4]</p>

Theme	<p>Illustrative quotes</p> <p>It hurts me so much and makes me think deeply about life, in that I should be able to look for means to make money or have a business that will help my partner and I sustain our family especially when ends are not meeting. [020 61163-0-7]</p> <p>These are things that are so burdensome for me to carry which does not need to include you but on my side it is hard....for instance if there is test carried and you fail I end thinking what really made me to fail this test but it is the result of angst of the mind, that is what happens in life.(Though participant is able to respond well to the questions asked one can sense the anxiety and feel the pain she is going through) [020-51124-0-3]</p>
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Table 4.8: Illustrative quotes on mother’s thoughts on making similar interventions acceptable and effective

Theme	<p>Illustrative quotes</p>
Peer groups and peer counseling	<p>If women can be given a chance to meet up together. The village health worker did tell us that we women must get together alone and get to discuss and help each other. I think if you love to do something you have all the confidence that if anything is to come, I am to accept it but if I am inside my home, I can never get to know what is taking place outside. Hence it is good to go out there and meet up with others. [020-51283-0-9]</p> <p>Those few who have understood must share the information and that next person shall share with another and it spreads until the job is done especially in hospitals all mothers must be forced to be taught these lessons, I see it becoming much easier [020-31914-0-8]</p> <p>Maybe you can teach us all mothers together as a group. They do teach us, who are part of the program but if they can teach us through as a ward meeting and it becomes a lesson for all women. Those who quickly understand things might learn something without having to get something. You should call us too those who are part of the of the program so that we can explain to others because we now have experience and we are able to explain why it is good and challenges faced in using the lessons, that is if there is anyone who has encountered the bad things but as for me I did not. [020-61145-0-7]</p> <p>If women can be given a chance to meet up together. The village health worker did tell us that we women must get together alone and get to discuss and help each other. I think if you love to do something you have all the confidence that if anything is to come, I am to accept it but if I am inside my home, I can never get to know what is taking place outside. Hence it is good to go out there and meet up with others. [020-51283-0-9]</p>
Lessons delivered by approachable, patient and respectful people	<p>If one is already in the program it is always important to let them know in an appropriate (respectful) way for them to understand especially with me, I do not think if I am to ever have grandchildren, they will definitely be well taken care properly of. [020-31914-0-8]</p> <p>It needs for the village health worker to be a patient person, someone you can easily talk to, and she must not be a village health worker who is unapproachable I should not be terrified when I do see her. She must be an open and approachable person and she</p>

Theme	Illustrative quotes
Lessons must be comprehensive Lessons should be delivered by professionals	<p>must not reproach me in a harsh toned voice when she finds my house dirty, she has to say it in a friendly manner that way I can easily accept it. [020-51206-0-4]</p> <p>This information must be conveyed to them comprehensively and they should be taught the importance of receiving these lessons. It might change their ways of doing things and they may be able to use the lessons [020-32026-0-3]</p> <p>If I am to share with others as an ordinary person that I am as black people they might find it hard to understand unless it is a professional who comes that is only when they can accept the information, but if it is someone from within the community they look down upon the information suggesting that my situation at home might be worse off compared to theirs so I am not really sure how best we can help each other I fail to understand it. [020-51184-0-9]</p> <p>It requires those from the health department to visit people they must visit door to door and see the state of their homes and encourage others to be hygienic so that people can change. It becomes difficult for someone like me to approach them they might retaliate by asking me to mind my own business. [020-51060-0]</p>
Providing incentives	<p>Maybe they should have promotions maybe to give incentives. For someone to be able to join a certain program that is if they are also getting something in return. Some did have toilets being built for them and other things may be that is other way to interest people, but as for me I did not join to have a toilet built for me it because I wanted to learn more. So, I think it is one of those things that might interest people because it is very rare indeed for someone to join a program without getting something in return. Maybe if we are to tell them of the benefits, we are getting they might be able to listen. [020-61145-0-7]</p>
Involving husbands	<p>Women do acknowledge things unless their husbands have something to do it because men are different. Some men do not acknowledge it and do not want to hear anything about it. As I was saying before I told you that I did talk to my husband about getting tested he did not respond he just went outside. I had my results, but he did not want to do so citing that the SHINE people were just after commanding people on what to do. It is not all of us who acknowledge things that come. [020-51283-0-9]</p> <p>The women should continue to receive lessons just the same way we received them because the program is still running, and I think they should cater for everyone not only for those who mothers who are pregnant and get to teach everyone I see it can help in enlightening the way of thinking of all the women.[020-51102-0-9]</p>
Lessons to involve everyone	<p>I think it might be difficult for women to take up this information because most women tend to think a lot. At times when receiving the lessons, I am busy thinking where on earth can I get the vegetables, or I could be thinking of my child who is going to school without a pair of shoes while at the same time I am receiving lessons. Therefore, if I am to receive lessons in this kind of state it becomes very difficult because there are lots of thoughts at play. [020-20949-0-4]</p>
Providing lessons for individual study	<p>There are books that the village health worker reads to us if they can give us those books too to read on our own it helps to grasp some of the lessons given by SHINE. [020-51216-0-5]</p>

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CHAPTER 5

CONCLUSION

Summary of results

Since the development of the UNICEF conceptual framework [1] for undernutrition that recommended a multi-sectoral approach to addressing nutrition-specific and nutrition-sensitive determinants of growth faltering, significant efforts have been made.[2] However, child undernutrition remains a daunting challenge with a third of the world's children considered to be stunted. Moreover, the number of children who are stunted is increasing and projections show that the global and regional targets for 2020 set by the WHO will not be achieved. [3] A recent conceptual framework by the WHO builds on the initial UNICEF conceptual framework and emphasizes inadequate complementary feeding, subclinical and clinical infection as particularly important causes of stunted growth.[4] The 2013 *Lancet* series on Maternal and Child Undernutrition [5] recommended evidence-based nutrition -specific and -sensitive interventions with strong theoretical potential to improve child nutrition outcomes by improving diet quality and limiting the burden of infection in the most vulnerable group. Research and programmatic strategies to achieve this have focused on direct nutrition interventions to improve complementary feeding and water sanitation hygiene interventions (WASH) to improve household and community level hygiene behaviours.

Complementary feeding interventions fall into several categories with the most common using behavior change communication (BCC) interventions to address specific infant and young child feeding (IYCF) practices. Other interventions also focus on closing micronutrient gaps by improving the availability and access to micronutrient supplements or fortified complementary foods. However complementary feeding practices are influenced by several things including

cultural beliefs, available food resources as well as the caregiver's willingness to adopt and sustain interventions. Intervention strategies have thus had mixed results for improving diet quality and stunting in different contexts. [6], [7] WASH interventions have focused mainly on household-level behaviors with very little focus on fecal oral pathways in children.[8] As a result, these interventions have had little impact on child health outcomes [9], [10]

There has simultaneously been increased attention on implementation science in the last few years, by both researchers and practitioners[11], [12] and a push to understand if, why, and how interventions work in different contexts to be able to scale up interventions. Implementation science can be viewed broadly as the science of understanding the best operational strategies for delivering and scaling up interventions.[12], [13] In the context of child health, however, all interventions are delivered through the caregiver and the household is the so-called “last mile” in the delivery path. It is therefore important to have an in-depth understanding of caregiver behaviours and household factors that drive these behaviours. This will allow for the identification of important aspects in the impact pathway that should be prioritized in scaling up to realize greater and sustained impact.

We aimed to contribute to these areas of research by evaluating the impact of a nutrition-specific complementary feeding (CF) and a nutrition sensitive WASH intervention on key maternal and infant behaviours in the context of a larger efficacy trial in rural Zimbabwe. All the interventions were developed after substantial formative research to identify key contextual factors.

First, in chapter 2, we evaluated the impact of the CF intervention on nutrient intake and consuming an adequate diet. The CF intervention aimed to improve the infant diets by improving the quality

and frequency of complementary feeding interventions. The interventions addressed key barriers to infant feeding identified during the formative research[14] through comprehensive BCC messages that targeted improving mother's knowledge and competence. The intervention also aimed to close micronutrient gaps through the provision of small-quantity, lipid-based nutrient supplement (SQLNS), that provided extra energy, iron and zinc. We were therefore able to explore how the intervention achieved impact by investigating the role of BCC vs SQLNS to elucidate what contributed to observed impacts.

In chapter 3, we evaluated if, what and how the WASH intervention achieved impact. The primary goal of the WASH intervention was to reduce exposure to vectors of faecal-oral microbial transmission in children younger than 24 months old. The intervention targeted mouthing and exploratory play, which were recognized as primary pathways for faecal oral microbial transmission among young children.[15] The intervention included BCC strategies to emphasize the importance of preventing children from ingesting visibly dirty objects as well as provision of inputs such as latrines, handwashing station, chlorine solution for water treatment and soap for handwashing. We used rigorous observation methods to identify whether key behaviours had been impacted in children.

In chapter 4, ethnographic methods were used to explore emic caregiver perspective on their own caregiving experiences and caregiving environment. Through a grounded theory approach, we identified specific components that influenced how the caregiver interacted with interventions. The results from these chapters and their implications for research and programming are summarized below.

(1) Nutrient Intake and complementary feeding practices

In Chapter 2, we evaluated the impact of a complementary feeding (CF) intervention that included behaviour change communication (BCC) and provision of small quantity lipid-based supplement (SQLNS). We specifically used the multi-pass dietary recall methodology to assess nutrient intake and investigated the impact of the intervention on (1) intake of macro- and key micro- nutrients (2) prevalence of adequate diet and, (3) infant consumption of different food groups. The results showed significant benefits of the intervention on intake of micronutrients, vitamin A, folate, calcium, iron and zinc (all $p < 0.001$) and on macronutrients fats ($p < 0.001$) and energy ($p < 0.05$). The impact of the intervention on protein intake was however not significant ($p = 0.083$). We also reported a significant effect of the intervention on the prevalence of adequate diet. In CF arms it ranged from low (26-29%) for folate and calcium; to moderate (59%) for energy to high (82-92%) for vitamin A, zinc, iron and protein. In the non-CF arms prevalence ranged from very low (1-11%) for calcium, folate and vitamin A; to low (40-50%) for energy and iron; to moderate (64-65%) for fat and zinc and high (82%) for protein. However, despite increased nutrient intake and prevalence of adequate diet, there was no difference between CF and non-CF groups in consumption of all food groups except for fruits and vegetables. Also, when the contribution of SQLNS to nutrient intake was estimated and removed there was no additional difference between the intervention and non-intervention households in the intake of nutrients from non-SQLNS complementary foods. These results are consistent with evaluations of similar interventions in Malawi [16], [17] and Ghana [18] that showed an improvement in nutrient intake with SQLNS provision and no additional contribution of non-SQLNS complementary foods.

I therefore interpret these findings as suggesting that

- a) SQLNS provided with BCC can effectively improve intake of key micro and macro-nutrients.
- b) BCC without a supplement in food insecure regions will not improve nutrient intake.
- c) Consequently, any impact of this intervention on health outcomes should note that in this population BCC only without a supplement SQLNS did not improve nutrient intake in this population. Hence both BCC and SQLNS are important for any health outcomes.

(2) Fecal-oral ingestion in 18-month-old infants

In the third chapter, a nutrition sensitive WASH intervention was evaluated. The results showed that despite the high-level of fidelity of implementation reported elsewhere [19] and the high caregiver motivation to take up interventions reported in chapter 4, the intervention was not fully effective. The intervention significantly reduced the likelihood of ingesting soil by 55% (odds ratio (OR) 0.45 95%CI [0.25,0.85]), visibly dirty cups or spoons by 41% (OR 0.59 (0.32,0.88)), visibly dirty water/beverages by 64% (OR 0.36 (0.18,0.68)), and shoes by 60% (OR 0.40 (0.17,0.91)). This suggests a significant reduction in faecal-oral exposure. However, these children were still exposed to high levels of contamination from visibly dirty hands, food and other visibly dirty objects. Visibly dirty hands and food were amongst the most frequently mouthed objects and were observed being mouthed by over 80% of the children regardless of intervention arm. There was no difference in the proportion of children mouthing these categories of objects. All children were also observed putting a visibly dirty object in their mouth at least once during a 6-hour observation period. We also found no effect of the intervention on infant

handwashing, mother's response to mouthing behaviours and presence of animal faeces in child's play area. This is consistent with results from caregiver reports in the main SHINE trial[19] and also in Kenya [20] and Bangladesh [21], where significant reductions in soil ingestion were reported however with persistent exposure to other vectors of faecal oral microbial transmission.

I interpret these results as suggesting that

- a) The WASH intervention, which provided a playpen and mat as well as messaging around protecting a child from eating dirty objects, reduced but did not eliminate ingestion of faecal-oral microbes among 18-month-old infants in rural Zimbabwe.
- b) Consequently, any reports on health outcomes should take into account this partial adherence failure showing that children remained exposed to substantial amounts of faecal microbes.
- c) Further, given that this intervention provided targeted WASH interventions for children and failed to eliminate faecal-oral contamination in children, it is highly unlikely that WASH programs typically implemented in rural areas of low-and middle-income countries and that focus on household -and community-level changes, will impact hygiene behaviours in children.
- d) WASH interventions should continue to focus on developing effective strategies to address contamination pathways introduced by mouthing and exploratory play in children less than 24 months old.

(3) Caregiving perspective and intervention uptake

The ethnographic exploration in the fourth chapter showed that women in rural Zimbabwe perceive their caregiving competence to be directly related to their child's health and well-being. If children were perceived to be healthy and generally well, then caregivers perceived and ranked themselves as highly competent caregivers while mother's whose children were not doing so well did not rank themselves highly. Women further reported that their caregiving decisions were influenced by different people who provided different types of caregiving information from general caregiving (bathing and doing laundry for the child) to specific and detailed information on how and what to feed their children and how to provide a clean, safe and hygienic environment for their child's health and development. In this caregiving environment most women perceived their Village Health Workers (VHWs) as the most accessible, relevant and important source of information. Consequently, their initial decision to take up and use the interventions that were delivered as part of the SHINE trial were primarily because of their interaction with the VHW. VHW's were described as knowledgeable, respectful, reliable and patient in providing lessons.

Continued use of interventions resulted from seeing health benefits in their children, with some women expressing that they could see health and development benefits (e.g. less hospital visits, hitting developmental milestones quicker, and better general well-being) in their current child that they did not see in previous children. This nurturant response to feedback from the child was the most important driver of sustained intervention use. They also identified several factors that also acted as motivators/facilitators and barriers of intervention use. These were classified into 4 broad groups (1) caregiving environment

(including themes and sub themes around perceived child health and well-being, family involvement, social support, cultural/social norms, resources and husband involvement), (2) maternal capabilities (with themes and sub themes around caregiver knowledge, self-efficacy and time, (3) intervention messages (with themes and sub themes around perceived ease/complexity of intervention, mode of delivery and duration of intervention lessons), and (4) intervention delivery agent (with themes and sub themes around perceived VHW knowledge, communication skills and reliability). Of note is the potential negative unintended consequences of the interventions on women's psychological health. Women, particularly those in Complementary Feeding (CF) intervention arms, who were unable to adopt intervention messages due to lack of resources reported deep feelings of helplessness and hurt. Some women even expressed that it would have been better not to receive the information because it was extremely hard on them as caregivers to be unable to adopt behaviors that they understood to be essential for their child's health.

I Interpret these results as suggesting:

- a) Nurture or the need for a healthy child is a strong determinant for caregiving practices, hence, CF and WASH interventions can benefit from incorporating nurture as a trigger for intervention uptake.
- b) BCC without supplementation (in food-insecure regions) may negatively affect mother's perception of her own caregiving competence and may undermine caregiving. Hence in food-insecure regions programs and interventions should not provide BCC without additional supplements.
- c) Caregiving practices and hence uptake and sustained use of interventions is influenced by several contextual, household, maternal, intervention and intervention delivery

factors. Programs should hence invest in extensive formative research to identify important factors in their context to facilitate better uptake and use of interventions.

Contributions to research and CF and WASH impact evaluations

1. We evaluated a novel intervention to reduce fecal-oral contamination in children less than 24 months

Checkley and colleagues [9] reviewed studies investigating the impact of WASH interventions on diarrhea and stunting and concluded WASH has a modest impact on stunting. A review in the *Lancet* in 2008, also concluded that available WASH interventions had the potential to reduce stunting by only 2.4%.[10] This body of research however represented interventions that were delivered at household- or community-level and measured impacts in children. None of the interventions addressed the main vectors of fecal-oral contamination in children, which are mainly mouthing of contaminated soil and objects [8], [15]. Although basic WASH interventions such as provision of latrines, water treatment and handwashing are important and can effectively reduce contamination in adults, infants often crawl and play in soil that is contaminated with feces from contaminated feet tracking in and out of play environments as well as human faeces and animal faeces. Mouthing of animal faeces, contaminated soil, unwashed hands and objects lying in contaminated soil present a pathway for faecal-oral contamination that is unique to babies and toddlers and is not addressed by available WASH interventions.[8] [15] [22]

We therefore developed an intervention that targeted this unique pathway of contamination by providing a play yard and mat to separate children from contaminated environments and BCC messages that emphasized infant handwashing and protection from ingesting animal feces,

contaminated soil and objects. We also provided conventional WASH interventions, which included latrines, handwashing, chlorine for water treatment as well as soap for handwashing. We evaluated the impact of the intervention using direct observation methods that identified and quantified the actual objects going into the child's mouth and hence allowed for the estimation of absolute rather than relative fecal oral contamination. This helped us have a better idea of intervention outcomes that might have been missed by using simple survey methods. Our results suggest that the intervention reduced but did not eliminate fecal oral microbial transmission in children. More research to understand more effective ways should be prioritized.

2. We highlighted the importance of BOTH SQLNS and BCC in impact pathways of the SHINE CF intervention

Evaluation of the complementary nutrient intake using in-depth, multi-pass methods showed an improvement in intake of macro- and micro-nutrients and prevalence of adequate diet. These results however resulted from the provision of both BCC and SQLNS. BCC only did not have an impact on nutrient intake. This is consistent with other studies that have shown an improvement in dietary intake with provision of a food supplement with or without the addition of a BCC component. [16]–[18] This suggests that in food insecure areas BCC without the provision of a nutrition supplement is not likely to have an impact on nutrient intake or health outcomes. This further highlight that scaling up efforts should prioritize SQLNS and BCC messages relevant for intake of other foods to ensure no displacement of other foods to achieve impact on health outcomes.

3. *We elucidated caregiver perspectives and household-level factors important for intervention uptake*

Ethnographic explorations of emic perspective of mother's in rural Zimbabwe showed that intervention uptake was influenced by various factors, but the major underlying construct was the interaction between mothers' actions and caregiving and the child's health and well-being. This suggests that nurture can be important as a trigger for intervention uptake. This is consistent with other studies that have used nurture in WASH interventions [23]

Further, our research showed that BCC in areas where mothers do not have the necessary resources to implement interventions can have negative effects on the mother's perception of her own caregiving competence and potentially undermine caregiving. Mother's expressed deep feelings about not being able to provide for their children especially when they know the potential health benefits. Consistent exposure to BCC messages when they lack resources to implement recommended behaviors may therefore undermine caregiving by making mothers feel less competent about their caregiving.

4. *We highlighted the importance of program impact pathways in evaluating CF and WASH interventions*

Reviews have shown mixed and mostly modest effects of CF [6] and WASH [9] interventions on health outcomes. What is not clear however is whether the lack of or the reported modest impact is a result of poor alignment of interventions with the causes of the health problem targeted by the intervention, leading to poor efficacy (theory failure), or failure to implement or adhere to interventions as designed (program/implementation failure or adherence failure). [11], [24], [25] Some studies that have reported some sub-analyses have sometimes reported

better impacts with implementation or adherence to intervention.[26] This shows that paying close attention to program implementation as well as understanding intervention uptake and adherence is important to strengthen causal inferences that can be drawn from the results of a study.

Implementation science research, which has emerged over the past decade has advanced understanding of the many possible issues with delivery and utilization that can limit the potential impacts of proven health and nutrition interventions [13], [24], [27]. Implementation research can be defined as “the scientific inquiry into questions concerning implementation—the act of carrying an intention into effect, which in health research can be interventions around policies, programs, or individual practices.” [13]. A key area in implementation research is the use of theory-driven process evaluation in impact-evaluation studies, which entails outlining how an intervention works through a program impact pathway (PIP). [11], [13], [24], [28]

This dissertation research was imbedded in the process evaluation as part of a larger trial that used a PIP approach to understand evaluation. As discussed earlier, a PIP is a structured approach of outlining “the pathway from an intervention input through programmatic delivery, household and individual utilization to its desired impact”[24]. A PIP outlines the theory behind intervention impact in a model that describes the causal chain and outlines program processes [11], [24], [28] allowing for the examination of all the steps in a causal pathway from “inputs to impact”. Analyzing intervention impact using a PIP approach can use mixed-methods to examine how the intervention is delivered, including barriers and facilitators; assess if the intervention is utilized and determine contextual factors that promote or limit its utilization all of which strengthens interpretation of impact evaluation results [11], [13], [24],

[27]. Such theory-driven approaches can provide information or plausibility statements that can strengthen explanation of positive, modest and insignificant results in an intervention study. They are also important in identifying key intervention components most responsible for the observed effects [11], [24], [25], which will inform the scale-up of efficacious interventions and programs. [11], [24], [28]

Causal inferences in studies of child growth studies assume that the intervention (e.g. BCC with or without supplementation or WASH) leads to the observed impact on growth. CF intervention trials assume that the intervention leads to better infant feeding practices, which in turn lead to increased intake of essential nutrients required for growth and ultimately lead to better growth outcomes in children. On the other hand, WASH interventions assume that the intervention leads to a cleaner environment which reduces the child's exposure to fecal microbes and leads to a reduction in clinical and subclinical infection and hence improved growth. Embedding process evaluation in these studies allows important questions in the causal pathways to be assessed, which strengthens the conclusions that can be drawn from these studies. Process evaluation can strengthen causal inference by providing additional evidence of the nature of association between the intervention and the outcome [29], can elucidate impact pathways and provide information to support a causal or a null finding. [11], [24], [28]. Table 2 below illustrates how process evaluation in this study strengthened causal inference and interpretation of the primary study results.

Table 5.1: Example of how process evaluation can strengthen causal inference and interpretation of WASH and CF interventions[#]

Intervention	Impact pathway				Interpretation
CF (BCC + SQLNS) / WASH (BCC + all inputs) intervention	Infant feeding/ WASH practices improved	Nutrient intake improved/ Fecal oral ingestion reduced	Improvement in biomarkers	Linear growth	
X	X	X	X	X	Implementation failure
✓	X	X	X	X	Engagement or adherence failure (first causal link)
✓	✓/X	✓/X	✓/X	✓/X	Partial engagement or adherence failure (first causal link)
✓	✓	X	X	X	Theory failure (early causal link)
✓	✓	✓	✓	X	Theory failure (later causal link)
✓	✓	✓	✓	✓	Consistent with theory
✓	✓	✓/X	✓/X	✓/X	Partial theory failure (works in some contexts)
✓	✓	X	✓	✓	Theory failure (different causal path)
✓	✓	✓	X	✓	Theory failure (different causal path)
✓	✓	✓	✓	X	Theory failure (different causal path)
[#]Adapted from Funnel and Rogers, 2011 [25]					
✓ = Outcome is observed					
X = outcome not observed					

The results of this study showed that there was an improvement in the nutrient intake and an increase in the prevalence of adequate diet as a result of the complementary feeding intervention. However, this intervention impact was due to the provision of SQLNS with no additional benefit from the BCC component of the intervention. This is an example of a partial adherence failure for

the BCC component of the intervention. Both the BCC and SQLNS components of the CF intervention were hypothesized to contribute to improved nutrient intake, but only a component of the CF intervention actually led to intervention uptake. In the ethnographic exploration study, women reported to have received the lessons but failed to take up the lessons as a result of shortage of resources which eliminates this as an implementation failure. They received the full BCC component, understood the importance of quality complementary feeding for their child's health, were willing to try the interventions however they failed to engage with or adhere to the intervention because they lacked resources and money to purchase fruits, vegetables or animal source foods for their children.

The SHINE study [19] reported a mean length-for-age Z (LAZ) score that was 0.16 (95% CI 0.08–0.23) higher and the mean hemoglobin concentration that was 2.03 g/L (1.28–2.79) higher in those in the intervention groups compared to non-intervention groups. The SHINE study also reported that in the CF arms the number of stunted children was reduced from 620 (35%) of 1792 to 514 (27%) of 1879, and the number of children with anemia also reduced from 245 (13.9%) of 1759 to 193 (10.5%) of 1845.[19] This positive impact of the SHINE CF intervention on child health outcomes is hence attributable to the provision of SQLNS as a component of the intervention.

Similarly, the WASH intervention results reported in Chapter 3 suggest a partial adherence or engagement failure. The baby observation study showed that there was a reduction in the ingestion of soil and some visibly dirty objects in the intervention children. However, they were still observed putting a lot of visibly dirty objects in their mouth in a 6-hour observation period. Additionally, the intervention had no impact on infant handwashing. The results of the overall trial showed that the WASH intervention had no impact on diarrhea and LAZ and stunting. [19] Two

trials that were similar to the SHINE trial in design and theory and were implemented in Bangladesh and Kenya also recently reported similar findings. [20], [21] These results may be strengthened by the findings that we reported in chapter 3 that showed continued extensive exposure to environmental contamination through object and hand mouthing and no improvements in infant handwashing. In in-depth interviews women reported that stopping children was one of the interventions they had problems sustaining, especially when children became older and more active. The play yards, which were provided to separate children from contaminated environments, were likely more effective when the children were younger and less mobile. However, when the children started walking, caregivers stopped using them because they were afraid children may hurt themselves, wanted their children to move around and explore their environment and also the children would cry. All this provides additional evidence of the partial adherence failure as women stopped using the play yard before children got to 18 months old.

Future research directions

This dissertation highlights several key areas that warrant further research in order to better understand and optimize CF and WASH research and programs, (1) First the BCC component of CF intervention had little nutritional benefit and most of the nutritional benefit of the intervention was due to the provision of SQLNS (2) the WASH intervention was partially effective in preventing fecal-oral contamination but not nearly complete, (3) this research used in-depth methods to assess behavior change which may not be sustainable for large-scale research and population level impact evaluations, (4) women's caregiving priorities and hence behaviors were primarily driven by a nurturant response. For each of these areas future research directions are discussed in this section.

1. *Feasible and sustainable ways to make SQLNS widely available*

Provision of SQLNS was very important for the observed impacts of the complementary feeding intervention. This shows that SQLNS is an effective intervention strategy to improve nutrient intake and hence health outcomes in food insecure regions. The SQLNS used in this study was imported from Nutriset in France and the formulation used was described by Arimond et al; 2015.[30] The cost of buying and shipping SQLNS may limit its feasibility and sustainability in scaling up this intervention. SQLNS is a peanut-based product and peanut butter is widely available in Zimbabwe. Hence locally producing SQLNS could make it widely available to mothers with young children in Zimbabwe. Research on the feasibility of local production of SQLNS is a clear next step in scaling up the results from this study. In Malawi [31], [32] and South Africa [33] efforts to produce SQLNS locally have been shown to be feasible and acceptable.

2. *Further research to understand effective BCC strategies for complementary feeding interventions in food -secure and -insecure areas*

Frequency of contact between behaviour change promoters and participants is sometimes not reported in CF research. [6], [26] However, in studies that reported frequency of contact, the most impact was reported when they provided intense BCC promotion with contacts varying from several times a week, weekly to fortnightly. [26] In this study the BCC contacts were once a month up to 12 months. Hence it is possible that more frequent BCC contacts between the caregiver and the village health worker (VHW) may have resulted in better intervention impacts. Further research to understand the ideal frequency of contact for intervention impact is critical for complementary feeding research and programs that use BCC strategies.

3. Further research to understand more effective intervention strategies to reduce fecal oral contamination

The WASH intervention evaluated in this dissertation showed modest improvements in fecal-oral exposure. It is therefore important to continue to investigate other intervention strategies that can be more effective in separating children from contaminated environments. It is important to identify, implement and evaluate interventions strategies that are culturally relevant and will (a) effectively remove animal from living environments, (b) effectively separate the children from contaminated environment, (c) effectively provide BCC messages to support maternal behaviors, (d) investigate safe ways to treat contaminated environments and (e) provide child friendly handwashing hardware to facilitate handwashing for infants

(a) ***Effectively removing animal from living environments:*** Animals are the primary source of fecal microbes in child play areas. In this study more than half the households in both intervention and nonintervention households had animal feces in or near the area where the child was playing. Other studies have also reported animal feces in child play areas [15], [34]–[36]. Animal feces have also been identified as the primary source of contamination of water sources [37]–[39] Due to the prevalence of free scavenging animals, most notably poultry in rural households in many low-income contexts, contamination with animal feces is extensive and much more prevalent than human feces. Therefore, removing animals or effectively keeping animals out of living environments should be prioritized. One strategy could be confinement of poultry; however, in some communities this may not be acceptable. In Zimbabwe [40] families

were unwilling to corral poultry because of the additional cost of providing chicken feed when chickens cannot forage freely. There could also be beliefs that may hinder the uptake of this interventions. For example, in a survey in Peru, families reported that chickens that were corralled all the time were likely to grow more slowly, gain less weight and die easily. [41] However in both Zimbabwe and Peru, chickens were corralled at night to prevent theft. An additional concern will be the health risk that can be associated with corralling chickens. In a randomized control trial in Peru that compared *Campylobacter* infections among children in households that corralled compared to those that did not corral chickens, researchers found higher rates of campylobacter-related diarrhea in children in the corral group, which they suggested could have been driven by the close proximity of corrals to households, children playing near corrals or inadequate hygiene among those cleaning the corrals. [41] In a follow up study conducted in the same population 10 years after the initial intervention, researchers reported positive attitudes towards corralling chickens, with most families citing that it helped them keep their living environment clean. [42] These studies can serve as a starting point in designing more strategies to remove animals from living environments effectively and address proper hygiene/management and adequate distance of corals from children playing environments.

(b) ***Effectively separating the child from contaminated environments:*** Mothers in the SHINE study reported that the play-yard and mat that was provided in this study was effective when children were younger. When they were older and more mobile, however it became less useful. Strategies to address this may include use of larger play areas. A study in Zambia recently developed a community-based play area to separate

children from contaminated environments. [43] The idea for the play area was based on using common cultural structures which are used by men for meetings or just to hang out. The area is relatively bigger than the play yard, allow multiple children to play inside and is easy to clean. If funding can be secured developing and evaluating similar culturally appropriate large play areas (particularly for older children) on exposure to fecal oral contamination and health outcomes should be prioritized as key next steps.

(c) *More effective BCC*: Health benefits from WASH on diarrhea and stunting are reported in efficacy studies that achieved high adherence through daily to fortnightly direct contact between the BCC promoters and study participants.[9] These behaviours were not sustained after the end of programs. Hence it may be important to ensure that frequent culturally relevant messages are designed to promote sustained uptake and use of these behaviours. It may not be feasible or sustainable to maintain daily or even fortnightly contacts hence, more sustainable methods to deliver BCC messages such as use of technology may need to be further investigated.

(d) Another potential strategy could be investigating chemicals that can be used to safely treat contaminated soil and reduce the enteric pathogen load. In some settings children eating contaminated soil, animal faeces and visibly dirty objects is considered beneficial for children to acclimatize to their environments. [15], [36] Hence shifting this norm may be difficult and alternative strategies that make soil relatively safe can be more effective

All of these proposed strategies will require testing for efficacy, scalability and acceptability, singly or in a package.

4. Critical assessment of the impact of interventions on health outcomes

The overall SHINE results show that the WASH intervention had no impact on stunting. [19] However it will be interesting to see if the observed reduction had an impact on more intermediate outcomes such as environmental enteric dysfunction (EED). EED is an active area of research and it is not clear how much reduction in fecal oral exposure is required to have a positive impact on the condition and other health outcomes. One sub-study within the SHINE study that investigated the impact of the WASH intervention on oral rotavirus vaccine reported that 10.6% (95% CI 0.54, 20.7); $p=0.031$) more children in the WASH group seroconverted post vaccination with oral rotavirus compared to the non-WASH group.[44] This suggest that, although the observed reduction in fecal oral exposure did not lead to improvements in stunting and anemia [19], it may have been enough to improve gut health to see an impact on oral vaccine. Further understanding of the required reduction in fecal-oral exposure to impact gut health will better inform intervention development for maximum impacts.

5. Further exploration of the effectiveness of interventions that address caregiver aspirations by using nurture as trigger for behavior change.

Caregiving priorities and behaviors for women in rural Zimbabwe was driven by a desire for the health and well-being of their child. This nurturant caregiver response to the child feedback has been reported elsewhere and shown to be universal across cultures. [45] In our ethnographic exploration, it was clear that this concept was central to how women

perceived themselves as caregivers as well as how they interacted with their caregiving environment and interventions that were introduced into that environment. This represents an important concept that may be incorporated into interventions as a trigger for maternal behaviors related to child care. Although the use of emotional triggers in gaining traction in changing adult behaviors, particularly hygiene behaviors, [23] their use is limited for behaviors that relate to child care. Child-care interventions instead focus on addressing knowledge gaps and equipping women with skills they need to adopt child care behaviors. [7], [46] These interventions have reported mixed results on child health outcomes. Therefore, developing interventions that address caregiver aspirations for their children and use emotional triggers may promote better uptake and effectiveness of behavior change strategies.

6. Further research to understand potential negative consequences of child-care interventions

Our results in chapter 4 showed a potential negative unintended consequence of the intervention on women's psychological health. Women who received intervention messages and were unable to implement them because of financial constraints or lack of resources expressed a feeling of deep hurt and helplessness over their inability to adopt the interventions. This also affected women's perception of their own caregiving competence. Given the importance of doing everything that they can to get a healthy baby, this maybe an important aspect that can affect women's mental health. This warrants further exploration in other context and assessing its impact on women's own health as well as infant health outcomes. Further, interventions to provide support for women's psychological health should also be investigated.

7. Developing and or validating simple measures of CF practices and infant exposure to fecal oral contamination

We used in-depth observations to assess infant hygiene and multi-pass dietary recalls to assess nutrient intake. The strengths of these methodological approaches are that they provide in depth information that can allow for more nuanced understanding of intervention impact. However, they are also very time consuming and expensive, which limits their usefulness. Simple survey-based measures for assessing complementary feeding were developed by the WHO, [47] but only one of the indicators, the minimum dietary diversity was extensively validated. To our knowledge no survey-based measures have been developed and validated to assess infant hygiene behaviors. As a result, priority should be given to developing simple survey-based measures to make it easier to study infant behaviors.

a. Develop simple methods for measuring fecal-oral contamination in children less than 24 months

The baby observation method used in this dissertation have been used in other settings [34], [36], [57], [58] to provide in-depth information on mouthing and exploratory play behaviors that expose children to fecal oral contamination. This method characterizes child's play extensively and can provide a wealth of information to identify areas for intervention development. The most commonly used version of the method involves observing the baby for a number of hours (usually 6 hours) and recording everything that the baby touches, or puts in its mouth, location of infant play, infant handwashing events, animal and animal feces present in infant play area and any other hygiene behaviors relevant to the child. This observation is ideally done by two researchers, one

following the baby, the other recording other household and hygiene characteristics of the infants play area.

The key strengths of this method are that it attempts to identify and quantify the actual objects going into the child's mouth and thus can be used to estimate absolute rather than relative fecal oral contamination. This level of specificity cannot be achieved using the limited structured questionnaires that attempts to get this information through caregiver recall. The major limitation of this method is that it requires substantial time and careful effort to collect and process the data. This potentially limits its usefulness in large-scale research trials and programs. Simple survey-based methods are important for use in these large-scale programs and population-level research. Resources and time can be saved through the use of these relatively easy to use indicators if they are as effective as the observation methods in characterizing infant mouthing and exploratory play behaviors.

Several large-scale trials [20], [21] including the SHINE trial [19], have begun to collect data using caregiver reports that ask them to recall if they have seen their child consuming soil and other animal feces. Although the use of these caregiver reports may seem appealing, there are a few problems; (1) none of the studies have validated these caregiver reports (2) they are prone to recall and social desirability bias, and (3) they cannot provide information on everything that the child puts in their mouth. In cultures where eating soil, animal feces or dirty objects is considered a good thing, caregivers may not pay attention to these behaviors, which limits the usefulness of any recall data collected with them. The SHINE trial collected both detailed baby observations as well

as caregiver reports of infant mouthing behaviors. The next step will then use this observation study to validate caregiver reports.

b. Validating WHO indicators for measuring complementary feeding practices

The strength of a causal inference that can be drawn from and supported by complementary feeding research depends on the study's internal validity. This means that the study design should minimize selection, information and confounding bias [48]. A study with a strong internal validity provides "strong unbiased inferences of the causality between the intervention and the impact indicator" [29]. In complementary feeding research several key issues can affect the quality of information collected introducing measurement error and hence threatening internal validity. First, complementary feeding is a complex multi-dimensional construct encompassing a range of issues such as responsive feeding, food diversity, frequency or density [49]. Hence the initial source of measurement error in complementary feeding research is at the level of defining and quantifying what is measured as "positive change in complementary feeding". It is also important to also note that most complementary feeding intervention studies usually do not address all dimensions of complementary feeding hence there could be a potential for greater impact with interventions that address complementary feeding more fully [7], [46], [50]. The second source of measurement error in complementary feeding research is the unavailability of reliable dietary assessment methods [51]. Interventions to improve complementary feeding aim to improve nutrient intake and common methods of assessing intake from complementary feeding are prone to bias and no "true gold standard exist" [51] on which to validate available measures [51]. Twenty four hour dietary recalls and food

frequency questionnaires are the most commonly used methods but both of these are prone to recall bias and cannot accurately estimate usual intake [51]. Studies that have validated these measures have shown that, depending on the context, specific foods or nutrients being estimated both methods can lead to over- or underestimation of intake [51]. All these issues weaken the internal validity and hence weaken the conclusions that can be drawn from impact evaluation studies looking at complementary feeding and growth.

In recent years the WHO complementary feeding indicators have been widely used to measure complementary feeding practices in programs and research. Although the multi-pass dietary recall provides more detailed information on dietary intake and is considered the “gold standard” for assessing complementary feeding, this method is not time or cost effective, which limits its use in large studies and population surveys. The WHO indicators were developed in 2008 to address the need for simple indicators to measure population trends in infant feeding, identify gaps in infant feeding practices and identify key areas for targeting [52]. To be able to measure population trends in large-scale surveys, the indicators have to be simple and practical yet valid and reliable [50]. The key strengths of these indicators are therefore their simplicity and ease of use to measure age specific complementary feeding practices in large population surveys such as the demographic health surveys and routine nutrition surveillance. Their simplicity, however, potentially limits their ability to measure complementary feeding effectively, which is a multi-dimensional construct encompassing a variety of interrelated practices [49]. Since their development in 2008, the WHO indicators have been incorporated in many countries routine demographic health surveys (DHS) and

have also been used in pooled analysis comparing trends in infant feeding across countries and regions [53] purposes for which they were developed. They have also been used for research to determine the impact of nutrition interventions and to assess determinants and consequences of poor infant feeding practices [53]–[55].

The WHO indicators have several weaknesses, which potentially limits their usefulness in CF research and impact evaluation. Only the dietary diversity indicator was extensively validated using standard methodologies [50] while all the other indicators were not validated. Hence it is unclear if the other indicators reflect the underlying construct that they are theoretically measuring, for example the minimal meal frequency does not have a clear guideline or cutoff or what constitutes a meal or a snack. The timing of complementary feeding does not capture the age of introduction of complementary feeding, instead it reflects whether or not a child consumed complementary food in the previous day. The minimum adequate diet indicator is a composite indicator so using it for intervention evaluation does not provide useful information on what the intervention actually affected. All these weaknesses potentially limit the usefulness of WHO indicators in rigorous studies where it is important to characterize specific components of the intervention that were impacted [56].

The multi-pass 24-hour dietary recall method, on the other hand, is an extensively quantitative method characterizing dietary intake. The method follows a multi-pass procedure where specific information on the food, quantities and preparation methods are collected [51]. The key strengths of this method are that it attempts to quantify

actual intake and can be used to estimate absolute rather than relative intake of energy and other key nutrients [51]. The multi-pass 24-hour recall is also open-ended and, thus can allow for any food and food combinations reported by participants. Therefore, this method has the specificity required for addressing change in complementary feeding research. This level of specificity cannot be achieved using the limited structured questionnaires used for WHO indicators [47]. This is particularly important in culturally diverse populations where a wide variety of food and eating habits may be present. [51] The major limitation of this method is that it requires substantial effort to collect and process the data [51]. This limits its usefulness in large-scale research trials and programs. Use of WHO indicator surveys in these large-scale programs becomes appealing. It is therefore important to assess the utility of WHO indicators in measuring intervention impact. Huge amounts of resources and time can be saved through the use of these relatively easy-to-use indicators if they are as effective as the multi pass 24-hour dietary recall in measuring intervention impact.

The SHINE study collected both the WHO indicators and in-depth, multi-pass dietary recall. The next step is to use the dietary data to validate the complementary feeding inferences drawn from this study, particularly assessing what is lost by using the summary measure, are the same conclusions drawn about complementary feeding in this population using these two methods. Specific areas that could be investigated include:

- Comparing the conclusions regarding minimum meal frequency using WHO indicators with consumption of adequate energy using the multi pass dietary recall methods;

- Comparing conclusions on minimum dietary diversity using WHO indicators with consumption of adequate iron, zinc and other key nutrients using the dietary recall method;
- The contribution to nutrient intake of the different food group that are included in the summary indicators.

Summary conclusions and recommendations

1. This dissertation showed that a complementary feeding (CF) intervention that consisted of a behaviour change BCC component and provision of small quantity lipid based nutrient supplement (SQLNS) delivered by community health workers to caregivers in rural Zimbabwe improved intake of key macro and micronutrients. Further analysis however showed that BCC alone had minimum nutritional impact and the provision of SQLNS in addition to BCC was important for improving child diets in this food insecure region.

Recommendation: Complementary feeding interventions in food-insecure regions should provide a food supplement to provide additional nutrients with BCC. However additional research to understand the frequency of intervention contact is also recommended.

2. The Water Sanitation Hygiene (WASH) intervention that targeted mouthing and exploratory play through the provision of a Blair VIP latrine, handwashing station and soap for handwashing, point of use water treatment, a play pen and mat as well as BCC messages around infant hygiene reduced but did not eliminate ingestion of faecal microbes by 18 months old children in rural Zimbabwe.

Recommendation: Research and WASH programming should promote the use of a protected play space with frequent BCC messages to promote hygiene behaviours particularly targeting mouthing and exploratory play in children less than 24 months. However additional research to understand new approaches to WASH delivery that effectively reduce faecal-oral transmission in children should be prioritized

3. This dissertation research also showed that in rural Zimbabwe caregiving decisions and hence intervention uptake is influenced by multiple factors, but the underlying dynamic can be characterized in terms of the of a nurturant caregiver response to child feedback.

Recommendation: Nutrition-specific and -sensitive research and programs may benefit from using nurture as motivator for behaviour change. They may also benefit from understanding and addressing contextual factors that may impact intervention intake.

4. This dissertation research discusses and provide an example of how using of a program impact pathway to assess how an intervention achieved its impact can provide important information along the causal pathway to strengthen causal inference.

Recommendation: WASH and Complementary feeding programs and research should propose a PIP and collect rigorous data at all stages to understand how interventions achieve impact and hence strengthen causal inferences.

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APPENDICES

Appendix I: Full schedule of intervention implementation

(Note: village health worker=community health worker)

Time	Intervention Implementation Activities			
	Standard Care	IYCF	WASH	IYCF+WASH
6-10 wks. gestation				
10-12 wks. gestation				
≤ 4 mo. gestation			Latrine construction	Latrine construction
5 mo. gestation	Encourage 1 st targeted ANC visit	Encourage 1 st targeted ANC visit	Encourage first targeted ANC visit Module W1 2 Tippy Taps delivered to household	Encourage 1 st targeted ANC visit Module W1 2 Tippy Taps delivered to household
6 mo. gestation	Encourage 1 st targeted ANC visit	Encourage 1 st targeted ANC visit	Module W2 Give soap.	Module W2 Give soap.
7 mo. gestation	1.EBF Module	EBF Module	EBF Module Module W3 Give Water Guard and soap	EBF Module Module W3 Give Water Guard and soap
8 mo. gestation	Encourage 2 nd targeted ANC visit EBF Module	Encourage 2 nd Targeted ANC visit EBF Module	Encourage 2 nd targeted ANC visit EBF Module Review safe disposal of feces in nappies Give Water Guard and soap	Encourage 2 nd targeted ANC visit EBF Module Review safe disposal of feces in nappies Give Water Guard and soap
9 mos. Gestation	EBF Module	EBF Module	EBF Module Review safe disposal of feces in nappies Give Water Guard and soap	EBF Module Review safe disposal of feces in nappies Give Water Guard and soap
BIRTH	Village Health Worker visits at Day 1, 3, and 7 after birth.	Village Health Worker visits at Day 1, 3, and 7 after birth.	Village Health Worker visits at Day 1, 3, and 7 after birth.	Village Health Worker visits at Day 1, 3, and 7 after birth.
1 mo. post delivery	EBF Module	EBF Module	EBF Module Give Water Guard and soap	EBF Module Give Water Guard and soap
2 mo. post delivery	EBF Module	EBF Module	EBF Module 2.Give Water Guard and soap	EBF Module Give Water Guard and soap

3 mo. post delivery	EBF Module EPI-1 reminder	EBF Module EPI-1 reminder	EBF Module Give Water Guard and soap EPI-1 reminder	EBF Module Give Water Guard and soap EPI-1 reminder
4 mo. post delivery	EBF Module EPI-2 reminder	EBF Module EPI-2 reminder	EBF Module Module W4 Give Water Guard and soap EPI-2 reminder	EBF Module Module W4 Give Water Guard and soap EPI-2 reminder
5 mo. post delivery	EBF Module EPI-3 reminder	EBF Module Module N1 EPI-3 reminder	EBF Module Module W5 Give Water Guard and soap EPI-3 reminder	EBF Module Module N1 Module W5 Give Water Guard and soap EPI-3 reminder
6 mo. post delivery		Module N2 Give Nutributter	Review Module W4 Review Module W5 Give Water Guard and soap	Module N2. <i>Infant's first solid foods</i> Review Module W4 Review Module W5 Give Nutributter Give Water Guard and soap
7mo post delivery		Module N3	Review Modules W4 & W5	Module N3 Review Modules W4 & W5
8mo post delivery		Module N4	Review Modules W4 & W5	Module N4 Review Modules W4 & W5
9mo post delivery	Measles immunization reminder	Module N5 Measles immunization reminder	Review Modules W4 & W5 Measles immunization reminder	Module N5 Review Modules W4 & W5 Measles immunization reminder
10mo post delivery			Module W6	Module W6
11mo post delivery				
12 mo. post delivery		Review N1-N5	Review W1-W5	Review N1-N5 Review W1-W5
13 mo. post delivery				
14 mo. post delivery				
15 mo. post delivery				
16 mo. post delivery				
17 mo. post delivery				
18 mo. post delivery	EPI-4 reminder	EPI-4 reminder	EPI-4 reminder	EPI-4 reminder

DR13	<p>Yesterday, how many hours during the day were you separated from your baby?</p> <p>Nezuro kwakachena , maawa mangani amakange musiri pamwechete nemwana wenyu?</p>	<input type="text"/> <input type="text"/> <input type="text"/>	Number of hours
DR14	<p>Yesterday when you were with your baby, did you breastfeed the baby whenever the baby wanted?</p> <p>Nezuro, pamakange muine mwana wenyu, maimuyamwisa chero paadira here?</p>	<p>Day <input type="text"/> <input type="text"/></p> <p>Night <input type="text"/> <input type="text"/></p>	<p>01 = Yes</p> <p>02 = No</p>
DR15 a	<p>Yesterday, how many times total during the day was the baby breastfed?</p> <p>Nezuro, kubva zuva richibuda kusvikira ravira makayamwisa mwana kangani?</p>	<p>Day <input type="text"/> <input type="text"/></p>	Number of times
DR15 b	<p>Yesterday, how many times during the night was the baby breastfed?</p> <p>Nezuro, makayamwisa mwana kangani husiku?</p>	<p>Night <input type="text"/> <input type="text"/></p>	Number of times
DR16	<p>Yesterday, did the baby eat about the same, more, or less amount of food than on a regular day?</p> <p>Nezuro, mwana akangodya zvakafanana, zvakawanda kana zvishoma pane zvemazuva ese here?</p>	<input type="text"/> <input type="text"/>	<p>01 = Same</p> <p>02 = More</p> <p>03 = Less</p>
DR17	<p>Was yesterday a usual day for the child? (probe for special events, illness, types of food, etc.)</p> <p>Zuva renezuro ränge riri semamwe mazuva here (bvunzisisa, mitambo, hurwere, mhando yekudya etc)</p>	<input type="text"/> <input type="text"/>	<p>01 = Yes</p> <p>02 = No</p>

DR18 : 24 Hour Dietary Recall

Now I am going to ask you about all the foods and drinks that the child had yesterday starting with the time the child awoke all the way through the night until the child woke up this morning.

Parizvino ndinoda kukubvunzai maererano nezvese zvekudya nezvekuwa zvakapiwa mwana nezuro kubva nguva yakamuka mwana, zuva rese kusvika paazomuka nhasi mangwanani

Episode	Time HH:MM	Food	Time Prepared	Amount		Mode	Recipe (Record Nutributter in separate column)			Nutributter
				Qty	Units 1=Cup; 2=Tbsp; 3=Tsp; 4=g; 5=ml		Ingredient	Qty	Units	Fraction of sachet
_ _	_ _ : _ _ _ _	_ _ _ _	_ _ : _ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _ _ _ _ _		
_ _	_ _ : _ _ _ _	_ _ _ _	_ _ : _ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _	_ _ _ _ _ _ _ _		

Appendix 3: Twenty-four-hour dietary recall data collection standard operating procedures

Introduction and overview

A 24-hour dietary recall is a dietary assessment method where an interviewer asks an individual to recall all the foods and quantities of food consumed in the previous day. The primary aim of the 24-hour dietary recall study within the SHINE study is to assess the change in the foods and nutrients consumed by children in the intervention and non-intervention arm. The goal is therefore to collect accurate and complete listing of all food and drink fed to babies.

The purpose of this SOP is to provide guidance for conducting the 24-hour dietary recall in the SHINE study using the multiple pass method in order to standardize methods. Generally, the first pass is a quick list of the foods eaten the previous day, and the subsequent passes collect more details on the foods such as recipe, cooking method, and quantity consumed. Throughout the interview, the DC probes for more information to get the most detail possible and to help the respondent recall any forgotten foods or details.

This 24-hour dietary recall will be used to assess complementary foods of infants enrolled in the SHINE study. In this case, a mother or other caregiver responsible for feeding the infant is the respondent. The use of probes is of great importance because other people may have fed the baby during the day.

Purpose

The objective of this document is to standardize:

The process of collecting 24 hour dietary recall data

Support and supervision of DCs

Quality control

Acronyms

DC- Data collector

RNS-Research Nurse Supervisor

NIM-Nurse Intervention Manager

FDS-Field data supervisor

RNC: Research nurse co coordinator

ADFO: Assistant Director Filed operations

FDC: Field data coordinator

ITS: Information, technology and statistics

Scope

- The scope of this procedure mainly involve the following departments
 - ITS
 - Head office ⇔ Database development, flagging of all participants selected into the 24 hour dietary recall sub study, ongoing support
 - Statistics ⇔ recruitment of participants
 - FDC ⇔ oversight of FDS and ensuring incorporation of 24 hr. dietary recall into regular activities
 - FDS ⇔ flagging of all participants recruited into the 24 hour dietary recall sub study, scheduling of visits and ongoing support
 - Biomedical research department

- DCs ⇔ collection of data, scheduling of visits
- RNS ⇔ Support and supervision of DCs, checking 24 hour recall for completeness, scheduling of visits, DC spot checks
- RNC ⇔ oversight of RNS and ensuring incorporation of 24 hr. dietary recall into regular activities
- Interventions and Communication
 - Graduate student/Research assistant ⇔ Support and supervision of DCs, Technical input, follow up of visits
 - Associate director ⇔ Overall support and technical input.
 - ADFO ⇔ Integration of procedure into routine SHINE measures including visit completion and data quality control, facilitating and managing relevant community engagement processes
 -
- Logistics
 - Buying and preparation of samples

Supplies and Materials

- 1 each of all the common household utensils, cups, bowls, and plates
- Digital kitchen scales (1 per fieldworker)
- Sets of standard US measuring cups with metric values (1 per fieldworker)
- Sets of standard US measuring spoons with metric values (1 per fieldworker)
- Clipboards (1 per fieldworker)
- Masking or lab tape
- Permanent markers

- Measuring jugs
- Tote bags (1 per fieldworker)
- Food storage containers (as available)
- Ziploc bags of different sizes
- Plastic storage containers such as Gladware
- Thermos
- Coldbox
- Cookware and utensils (sauce pans, frying pans, stock pots, stirring spoons, knives, cutting boards, plates, bowls, table utensils)
- Kitchen with freezer/refrigerator
- Dish soap
- Dish rags
- Dish towels
- Food samples

Procedures

Scheduling and preparing for visits

FDS responsibility:

FDS should keep a list of all PTIDs selected into the 24 hour dietary recall sub study and should check this list against all flagged visits in the database.

For all PTIDs selected into the dietary recall sub study the FDs/RNS assign 12 month visit to trained DCs.

RNS responsibility:

1. Print and keep a list of all PTIDs enrolled into the dietary recall sub study. Check the list against the database regularly and confirm eligible PTIDs.
 - a. In the case of any discrepancies, RNSs should confer with FDS and double check with the head office before assigning DC visits.
2. Conducts regular spot checks to ensure the DCs carry all require samples to the field and collected 24-hour dietary recall data inline with the SOP.
3. Review and approve DCs requests to purchase samples

DC responsibility:

1. Each DC verifies the PTID against the list of all women recruited into the 24-hour dietary recall using the list that is generated by the FDS/RNS.
 - a. Any discrepancies should be brought to the attention of the FDS/RNS
2. Check that the 24 hour recall form is available on their netbook before they go to the field
3. Carry all required materials to conduct the visit
 - a. The digital scales should be calibrated every morning
4. Prepare all required samples for the visits

Note: it is responsibility of the DC to

- *Request for ingredients required to prepare samples e.g. sadza and ensure that the samples are prepared in a timely manner. The RNS should regularly check that the DC is preparing and taking samples to the field.*
- *Check that they have all the required materials to conduct the 24-hour dietary recall visits.*

Interventions & Communications responsibility:

Graduate student/Research assistant responsibility:

1. Selection of PTIDs into the dietary recall sub study
2. Verifies that all eligible PTIDs are visited for the 24 hour dietary recall
3. Provide timely feedback for any missed visits
4. Conduct regular spot checks to ensure adherence to protocol during data collection

Note: It is the responsibility of the Graduate student/Research Assistant to ensure

- *All eligible PTIDs are visited*
- *Verify with the ITS department that the correct PTIDs are flagged for the dietary recall visit.*
- *Verify that all data collected is complete and consistent*

24 hour dietary recall procedure

DC responsibility:

1. DC collects all the required materials and check netbook for all required forms before they leave for a visit.
2. When they get to the household, explain to the mother the purpose of the visit and collect the data using the detailed procedure below.

Introduction

The interview begins with the DC introducing the 24-hour recall. A sample introductory script reads as follows:

Today I'm going to ask you about the foods the baby ate yesterday as well as some general questions about yesterday: how the baby was feeling, what was the day like, etc. During this discussion I will ask you details about the recipes and quantities that you fed to the baby. If you have any questions, do not hesitate to ask me. Are you ready to begin?

First, the DC asks a series of questions to learn about the previous day. Questions include:

- Morbidity
- Breastfeeding Frequency
- Breastfeeding On Demand
- Hours Separated from Child

These questions also include questions on whether the previous day was a usual day. If it was not usual, probe the mother on why it was not a usual day (e.g. travel, holiday, wedding, sickness, etc). These also include a question on whether the amount of food that was consumed by the infant was the same as usual, less than usual, or more than usual.

The interview protocol includes the multiple pass method. The multi pass method is a method that collects the details of the food to the baby in several passes starting with a simple list of food, then going to get more details about how the food was prepared and the quantities fed to the baby. The DCs will collect the dietary recall data for the SHINE study in 5 passes which are fully described below.

Pass 1

The first pass is just a simple list of the foods eaten on the previous day and the time of day that they were eaten. The DC should follow the following steps for the first pass

1. Ask the mother to recall the first food the baby ate at a standard time on the previous day, from the time when the baby awoke.
2. Writes a "1" in the first "Episode" blank, the time of day in the first "Time" blank, and the name of the food in the first "Food" blank. If the baby ate more than 1 food at this time, the DC records each food on a different "Food" line. The DC will put a "1" in the subsequent "Episode" blanks and the same time of day in the subsequent "Time" blanks for each of the foods consumed at the same time.
3. Ask the mother to recall the next food the child ate and so on. The ending time of the recall is 24 hours after the start time, i.e. up to the time the child awoke on the current day.
4. Records separable ingredients in mixed dishes as separate foods in the episode. These types of foods include pieces of meat in stews, pieces of potato in stews, etc. This is important because mothers may or may not feed these ingredients when they feed the stew, and each bite may not contain the same quantity of ingredients in each bite or serving. Beverages such as juice, milk, tea, and soda should be listed as individual foods.
5. Record all food that was offered to the baby. If the baby did not eat the offered food record the food under pass 1 and record zero for the quantities that the baby consumed in pass 4. Make sure you probe (mother may only mention food that

the baby ate and not mention what was offered) for all food that was offered and not eaten.

6. One episode should be defined as any foods eaten within a 30minute time interval. Therefore, if a baby ate a biscuit at 10:15 am and then ate a piece of mango at 10:45 am, both foods would be recorded as the same episode number.
7. To help the mother remember the times the baby ate, probe mother about her activities on the previous day to help her remember. For instance, “So after you fed the baby porridge at 8am, what did you do?” Probes may include sweeping, going to the garden, going to the market, preparing food for other people, washing dishes, giving the baby to someone else to watch/feed, purchasing foods for the baby from the market, etc. Since breastfeeds were asked about at the beginning of the interview, it is not important to record breastfeeding episodes. However, if it helps the mother to recall other foods throughout the day, then allow the mother to mention each breastfeeding episode.

Pass 2

On the second pass, the DC goes through the following steps

1. For each food ask the mother if she has forgotten any foods.
2. To help the mother remember the times the baby ate, the DC can probe her about feeding episodes on the previous day For instance, “What was the first food you fed to the baby, what was the second etc.?” Note: in the first pass the DC is using the mother’s activities to probe while for the second pass the DC is probing using feeding episodes.

Pass 3

On the third pass, the DC goes through the following steps

1. For each food ask the mother to recall the recipe for each food including any enrichments added at the end of cooking prior to serving such as Nutributter, milk, butter, oil, sugar, peanut butter, seed powder, etc.
2. Amounts of ingredients may be weighed if they are readily available in the house or available as part of the samples that the DC is carrying. Alternatively, the mother may give amounts in terms of household measures it is all right to record just the household measure.
3. Use standard household measures to record. If the ingredient has not been weighed, have the mother pour the equivalent amount of water into the household measure, and then weigh the amount of water. Water's density equals 1 g/ml. Therefore, the weight of water is equal to the volume. Record the volume of ingredient.

Pass 4

On the fourth pass, the DC goes through the following steps.

1. For each food and drink asks the mother to recall the quantity of food consumed. It is important to emphasize to the mother that we want to know how much of the food the baby swallowed, NOT the amount of food she served to the baby. If the DC has samples of the food, the mother can dish out the amount eaten by the baby into her own dishes. This can then be weighed and recorded in the "Amount _____(g)" blank. One food sample can represent several similar dishes. For instance one green leafy vegetable can represent all green leafy vegetables or

plain porridge can represent all porridges with small amounts of added enrichments.

2. If there is no food sample, ask the mother if she still has the food in the house. If yes, then have her dish the amount of food eaten into her dish, and weigh that amount.
3. If no and the food is semi-solid (rice, porridge, sadza, etc) or liquid, then ask the mother to pour the equivalent amount of water into the household measure, and then weigh the amount of water. If the food is a solid such as a piece of fruit, ask the mother to describe the quantity in terms of size, and portion of unit size (e.g. ½ of a small banana).
4. Asks the mother how the infant was fed (by the mother/other person with spoon, cup, bottle, or hand or by the infant himself with a spoon, cup, bottle, or hand). The DC records this in the “Mode” blank.
5. If there is a food that was fed to the baby by someone else, the interviewer asks if that person is around so they can give details about the food and quantity of food consumed. If the person is not around, then ask the mother if she can estimate the details. At the minimum, record the food.
6. If food was offered but the baby did not eat, record zero in the quantity consumed column.

Pass 5

The final pass is the DC going over the list of foods one last time. The DC asks the mother if there is anything that has been forgotten.

After the final pass, The DC thanks the mother for her time, and ask her to put away any food, ingredients or materials that have been used during the recall. While the mother is doing this the DC can use the time to go over the netbook entries and check for any missing data or data that has been inappropriately recorded. This is important to remember so that ingredients that are added at the end of cooking, prior to serving, are not left off the form. After this the DC can continue with the 12-month visit as necessary for the research study.

Assessing quantity of food consumed in interview

Based on the previous formative work and pilot work sadza, thick porridge, thin porridge, tomato and onion paste are the foods mainly fed to babies. For these interviews the DC must prepare samples of these foods before each visit and during the interview ask the mother to spoon out the quantity of food consumed by the baby into his/her personal dish. The DC should then measure this portion of food and record as the total consumed by the infant. At the end of the day refrigerate the samples to use for the next visit.

Problems/Things to be aware of

- Beware of the samples being placed in the freezer instead of the refrigerator. The samples may not be thawed by the time of the interview. The RNS should have regular communication and spot checks with all interviewers.
- Scooping food in and out of the thin Baggies can be messy. DCs should ensure they do not take shortcuts and just have the mother point out in the bag how much the child ate instead of dishing out the food on to her own dish.

- Hot foods may melt the plastic bag if you do not allow time to cool before portioning out the sample.
- If you forget to prepare samples ahead of time, this may cause you to be late or may cause the foods to not be prepared in the manner you desire.
- Porridge and sadza will harden and not be the consistency that you need them to be when showing them to mothers.
- Other children in the home may ask to have the food samples because they are hungry. Sometimes this is ok if the food is freshly prepared and has been stored safely. Otherwise it is best to explain that the food is old and likely not safe for consumption.

Quality Control

At the end of the day the DC submit interview together with the rest of the 12-month form to the RNs for completeness check. The RNS supervisor reviews completed forms on the day of the interview. Any missing information should be pointed out to the DC and filled in appropriately. If it is feasible to return to household, the RNS will tell the DC to return and acquire the missing information. If it is not feasible to return to the household, have the interviewer fill in as much missing information as possible by memory. The research assistant will provide technical input to the DCs and conduct regular spot checks.

Due to the qualitative and subjective nature of the data the following additional procedures will be followed to ensure data quality

1. Support visits

- The research assistant will support DCs regularly and will accompany and debrief with them for their first 3 visits to ensure protocol adherence
- The RNS should also attend these 3 visits with the research assistant and lead the debrief sessions for the 2nd and 3rd visits
- At the end of these 3 visits the research assistant will assess DC competence and provide additional support on a case by case basis

2. Spot checks

- The RNS and research assistant will conduct spot checks to ensure protocol adherence. For at least 2 of the DC visits the RNS will collect pass 1 and pass 4 data and compare it with the DCs for consistency and accuracy. For this the RNS will visit the same PTID that the DC has visited on the same day after a DC visits.

3. Quality reports

- The RNS will compile monthly quality reports to be shared with the Research assistant
- The research assistant will put together the hub reports into one report to be shared with the respective heads of departments
- Each quality report should include information on
 - Visits due
 - Visits completed
 - Spot checks completed
 - Indicators of how well the visits have been don (can be qualitative)
including the following information
 - How different the DC data is from spot check

- Any gaps identified
- Areas the DC may need additional support

4. Data summaries

- The graduate student will review data every month and provide a summary report on
 - i. Completeness
 - ii. Consistency
 - iii. Plausibility
- For the first month of data collection the data summary will be done twice (after the first 2 weeks and at the end of the month)

5. Team debrief meetings

The research assistant, graduate student and associate director implementation science will meet regularly via Skype to debrief and trouble shoot.

Appendix 4: Twenty-four diet recall: protocol for converting recipe files into nutrient database

ACRONYMS

SHINE: Sanitation Hygiene Infant Nutrition Efficacy Trial

PTID: Participant ID

1 Materials

Before you start make sure you have the following on your computer

- Nutrisurvey installed (check that you have the libbensmittel file in the c drive)
- 2 recipe files
 - Kerian Paul full recipes database
 - Amy Desai full recipes database
- 3 SHINE dietary recall files
 - Introduction file
 - Recall file with the following columns: ptid, visitcode, episode, stime, food, code, Actual food, Nutributter (grams), timeprepared, quantity, units, mode, pass, weight (g)
 - Recipe file with the following columns: ptid, visitcode, episode, ingredient, food, quantity, units, nutributter, weight
- Cheat sheet
 - A sheet detailing what foods were names in previous work
- A list of all PTIDs enrolled into the dietary recall substudy

2 Data Structure

All the dietary data was entered into a database with the following levels of data

- Introduction
- Recall
- Recipes

The introduction data contains demographic questions for each participant. These include

- Participant ID: PTID
- Date
- Morbidity
- Breastfeeding episodes
- Hours separated
- Usual day
- Usual amount of food

The Recall data includes

- A list of all food consumed in the last 24hours,
- The time food was prepared
- The time food was fed to the baby
- The quantity fed to the baby
- The quantity of the unit of the amount fed to baby
- Feeding mode

The recipe data include

- A list of ingredients for all the food listed under the recall
- Quantity of each ingredients
- Quantity unit for each ingredient.

All the 3 levels of data were exported to excel for use in creating the nutrient data base.

3 Procedure

Before you begin entering data for a given PTID please check that you have an introduction, recall and recipe record for the PTID. After you ensure you have a complete record for a given PTID go through the following steps

STEP 1: In the recall file highlight all the food listed for the PTID

STEP 2: For each listed food check how much was fed to the baby by checking the “quantity” column. Convert the quantity fed to the baby into grams (if its not already recorded in grams) and complete the “Weight (g)” column

STEP 3: Open the recipe file and check that every listed food in the recall file has a corresponding recipe in the recipe file

STEP 4: Select the first food listed and go through the recipe and check all the ingredients, then compare for similarity with the closest recipe in Amy or Kerian recipe files. Check the ingredients closely because the name recorded may not reflect all the added enrichments. For example porridge with peanut butter may only be titled “Porridge”, and another porridge may be titled Porridge-peanut butter, but ingredients may include sugar. Therefore it is important to thoroughly check all the ingredients before choosing the closest recipe in Amy or Kerian recipe file to compare with.

STEP 5: Once you identify the recipe that is similar or close enough to your recipe, go to the nutrisurvey file and find the correct food name (you may use the cheat sheet to identify how certain foods are named in nutrisurvey).

STEP 6: Copy the food name from the nutrisurvey file and paste it to the “Actual food column” in the recall file

STEP 7: Copy the food code from the nutrisurvey file and paste it to the “code” column in the recall file.

STEP 8: Go through STEP 4-7 for all the foods listed in the recall file (one at a time).

STEP 9: In the “Selected PTIDs document record the date when data was completed).

NOTE For recipes that include nutributter record it in a separate column in grams

4 Making decisions about recipes

The following is a rough guideline for making decisions about recipes. You may come across some situations that are not covered in these guidelines

- For sadza, the recipe is the same. Once you come across sadza you don't have to compare recipes for similarity, go straight to the nutrisurvey file and use food code: _193313, Actual food name: Sadza (monica 3)-2
- For porridge
 - If the water: mealie-meal ratio is 1:6 consider this a thick porridge
 - If the water:mealie-meal ration is less that 1:6 consider this a thin porridge
- In all recipes the following ingredients should be examined closely as small differences in their quantities have a large effect on the nutrient intake. Please note that this is not an exhaustive list but a rough guideline based on the common ingredients for rural Zimbabwe.
 - Sugar, cooking oil
 - Eggs, beans, meat, fish, peanut butter
 - Green leafy vegetables

- For dried vegetables use the “boiled vegetables” recipe
- For milk check for fortified vs unfortified milk
- Water has a specific code that is standard
- Outlier weights should also be identified and investigated (e.g. 200 cups of water)

5 Recipe conversion units

The following is a rough guideline for unit conversion which may be useful if you are comparing 2 recipes with different units, again you may come across some situations that are not covered in these guidelines

1 cup = 48 teaspoons = 16 tablespoons

$\frac{3}{4}$ cup = 36 teaspoons = 12 tablespoons

$\frac{2}{3}$ cup = 31.7 teaspoons = 10.6 tablespoons

$\frac{1}{2}$ cup = 24 teaspoons = 8 tablespoons

$\frac{1}{3}$ cup = 15.8 teaspoons = 5.3 tablespoons

$\frac{1}{4}$ cup = 12 teaspoons = 4 tablespoons

$\frac{1}{8}$ cup = 6 teaspoons = 2 tablespoons

1 cup = 237ml

$\frac{3}{4}$ cup = 177.4ml

$\frac{2}{3}$ cup = 156ml

$\frac{1}{2}$ cup = 118.3ml

$\frac{1}{3}$ cup = 78ml

$\frac{1}{4}$ cup = 59ml

1 tablespoon = 15ml

½ tablespoon = 7.5ml

1 teaspoon = 5 ml

½ teaspoon = 2.5ml

6 New recipes

a. Adding a recipe to nutrisurvey

7 Quality control

- How to create recipes – to avoid duplicates
 - For every new recipe we should consult and decide how to add
 - Make sure to update new nutrisurvey recipes file on all computers
- How to protect the data- i.e. avoiding deleting data
 - Save regularly
 - Backing up data at the end of everyday
- Data access and saving
 - Make sure save all the data in the two locations below so there is a back up
 - SHINE Server
 - Cornell box

Appendix 5: Baby observation data collection form

Address these questions to mother:

1. Caretaker's sex (If not the Mother please specify the relationship_____)

Male

Female

2. Caretaker's/Mother's highest completed level of education

None

Grade 1 Form 1

Grade 2 Form 2

Grade 3 Form 3

Grade 4 Form 4

Grade 5 Form 5

Grade 6 Form 6

Grade 7 Additional years of tertiary education

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3. How many children live in this house hold for the last three months? _____

4. Caretaker's/Mother's marital status?

Married

Cohabiting

Separated or divorced

Single - never married

Widow

Other (specify) _____

Observe for the following:

1. Is there a latrine for the household or do they use the neighbor's?

- Household has own latrine
- House hold uses neighbor's latrine
- Household does not use latrine

2. Does the latrine have a vent pipe?

- Yes
- No

3. Does the ventilation work?

- Yes
- No

4. Is the latrine full?

- Yes
- No

5. Evidence of use (trodden path test)?

- Yes
- No

6. Is there a hand washing station?

- Yes
- No

7. Is there soap near hand washing station?

- Yes
- No

8. Is there evidence of a recent hand washing event (Tick all that apply)?

- Yes, water on the ground next to Hand washing station
- Yes, container/tippy tap with water
- No clear evidence

- Couldn't tell because it was a rainy day
- Other, specify (_____)

9. Observe the following

Drinking water storage container	Covered?		
	Not	Partially	Completely
Drum	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20-25l Plastic container ("jerry can"/ narrow	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bucket	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Clay pot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. Observe the following Household and Baby's Characteristics (Circle the number for the appropriate choice)

	On arrival	At 6 hours
Time (use military time)		
Planned	__ : __	__ : __
Actual	__ : __	__ : __
1. Mother's hands visibly clean	1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
2. Baby's hands visibly clean	1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
3. Diaper or child's bottom is clean	1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
4. There is stagnant water visible	1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
5. There are unwashed utensils	1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
6. There are uncovered Utensils	1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
7. There is uncovered food that is not being eaten	1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see

		On arrival	At 6 hours
<i>Time (use military time)</i>	Planned Actual	__ : __ __ : __	__ : __ __ : __
8. Smooth concrete kitchen floor		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
9. Dirt or cow dung kitchen floor		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
10. Spill on kitchen floor (food or drink)		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
11. There are poultry feces visible on kitchen floor		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
12. There are animals in the house. Specify _____		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
13. Kitchen yard is swept		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
14. Area where child plays is swept		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
15. There are poultry feces visible on yard		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
16. There are human feces visible on the yard		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see
17. There are animal feces visible on the yard, specify _____		1 Yes 2 No 3 Cannot see	1 Yes 2 No 3 Cannot see

11. Number of animals present in the yard at the time of observation

	On Arrival		At 6 hours	
	Corralled	Not Corralled	Corralled	Not Corralled
Domestic Animals				
Cattle				
Goats				

	On Arrival		At 6 hours	
Domestic Animals	Coralled	Not Coralled	Coralled	Not Coralled
Pigs				
Dogs				
Cats				
Chickens				
Guinea fowl				
Ducks				
Other				

13. Infant handwashing

Infant's Hand Washing	HW #1	HW #2	HW #3	HW #4	HW #5	HW #6	HW #7	HW #8
Time (use military time)	__ : __	__ : __	__ : __	__ : __	__ : __	__ : __	__ : __	__ : __
1) Hand washed (Enter: 1= Left hand; 2= Right hand; 3= Both hands)								
2) Water use, (Enter: 1= running water; 2= still water)								
3) Scrubbing agent, (Enter: 0=none; 1=soap; 2=ash;3=other)								
4) Drying material, (Enter: 0= no drying; 1=Vis Dirt towel/clothes; 2=No Vis dirt towel/clothes; 3 = wet towel/clothes; 4 = dry towel/clothes)								
5) Observe triggers for hand washing. (Enter; 1=after defecation; 2= before eating;3=after crawling on dirt floor, 4 =after eating; 4=Others (Specify/write down))								
Total # of HW events								

14. Infant nappy changes

<i>Record first three nappy changes after defecation per visit.</i>	Defecation 1	Defecation 2	Defecation 3
Time (use military time. If no nappy changes occur, write 99:99)	__ : __	__ : __	__ : __
1. Who initiated cleaning the child (Enter: 1=child indicated need; 2=caregiver; 9=not able to observe)			
2. What was done with the fecal material (Enter: 1=disposed of via toilet/latrine; 2=wrapped up for disposal in garbage; 3=buried; 4=tossed in yard; 5=left untended for > 30 min; 9=not able to observe)			
3. How was the child's bottom cleaned? (Enter: 1=soap and water; 2=rinsed only with water; 3=wiped with cloth only; 4=Wiped with paper; 9=not able to observe)			
4. Did caregiver wash his/her hands within 5 min after cleaning the child's bottom (nappy change)? (Enter: 0 = none/no: 1=one hand; 2=two hands;3= water only/no rubbing agent;4= Soap; 5= ash; 6=other; 7=run to waste water; 8= still water; 9=unable to observe)			
5. Did caregiver wash his/her hands within 5 min after assisting a toddler to clean up after defecation? (Enter: 0 = none/no: 1=one hand; 2=two hands;3= water only/no rubbing agent;4= Soap; 5= ash; 6=other; 7=run to waste water; 8= still water; 9=unable to observe)			
6. Is the drying material for Infants hands clean? (Enter: 0= No drying; 1= Visibly dirty; 2 = no visible dirt; 3 =wet; 4= dry)			

15. Infant play yard use

Infant's Play yard	PY #1	PY#2	PY #3	PY#4	PY #5	PY#6	PY #7	PY #8
Time (use military time)	__ : __	__ : __	__ : __	__ : __	__ : __	__ : __	__ : __	__ : __
a)Who Is in the PY (Enter: 1= infant alone; 2= mother in PY with child 3= Other children in PY)								

Infant's Play yard	PY #1	PY#2	PY #3	PY#4	PY #5	PY#6	PY #7	PY #8
b)Child activity, (Enter: 1= sleeping; 2= Playing 3= feeding 4= other)								
c)Play yard condition, (Enter: 0=clean; 1=visibly dirty)								
d) Where is the PY set up (Enter 1= inside the house 2. Outside in the Yard 3. Close to a dangerous object e.g. fire, open well)								
e) Other things in the PY: (Enter 0= nothing; 1=clean toys 2=visibly dirty toys; 3 = animals 4= Other)								
f) What is the condition of the baby in the PY (Enter 1= Visibly dirty 2= Clean)								
g) Triggers for PY use. (Enter; 1=mother busy 2= baby crying;3 other)								
h) Triggers for taking the baby out of PY (Enter; 1= baby crying; 2= mother playing with baby 3: other)								
Total # of PY events								

16. Record any comments on infants handwashing, feeding, play yard and nappy change episodes following instructions in the filed observation guide

17. Comments on the general cleanliness of the kitchen yard (Trash on the yard, any presence of decomposing material and flies, waste water thrown within the yard, left overs etc):

18. Record any other relevant activities that may influence the fecal oral contamination routes in babies

Appendix 7: In-depth interview guide

Introduction

Thank you for talking with me today. We are interested in learning more from the mothers about their experiences as mothers. We will ask you questions about your experience and opinions taking care of [Index child, I haven't had the opportunity yet to be a mother and hence have no experience with caregiving. I'm happy to talk to you and learn from your experiences. There are no right or wrong answers—you're the expert.

Question

Purpose

General caregiving

What comes to your mind when you think about taking care of [Index child]

To get their thoughts and perceptions on what care is and what they consider to be good caregiving activities.

I know there are lots of things that you have to do to take care of babies. In your experience what do you think are the most important ones.

To get a of caregiving priorities

All mothers try to be good mothers. In your opinion are some mothers better than others? Why?

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Question

In your experience what things did you have to consider in deciding how to take care of [Index child]

- Time, cost, health benefits for the child

Purpose

Caregiving around Infant feeding

Now I would like to talk to you about how you are how you are feeding [Index child]

Now that [Index child] is [x] months old. What foods are you giving? Why?

We have this data already quantitatively; this is just meant to give a quick sense of what they consider the typical infant feeding practices for index child.

- Baby's age, baby's needs
- Source of Infant feeding knowledge
 - Probe for advice from significant others (mother in law)

Introduction

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Question

Purpose

- Social norms
- Power to make infant feeding decisions

Are there any foods you would like to give [Index child] that you are not giving her now? Why are you not giving these foods now?

- Baby's age, baby's needs
- Source of Infant feeding knowledge
 - Probe for advice from significant others (mother in law)
- Social norms
- Power to make infant feeding decisions

Introduction

Thank you for talking with me today. We are interested in learning more from the mothers about their experiences as mothers. We will ask you questions about your experience and opinions taking care of [Index child, I haven't had the opportunity yet to be a mother and hence have no experience with caregiving. I'm happy to talk to you and learn from your experiences. There are no right or wrong answers— you're the expert.

Question

Purpose

Do you think this is the best way to feed [Index child] Why or Why not? To get a sense of perceived negative and positive infant feeding behaviors

Caregiving environment

In addition to you, is there anyone else who feeds the baby? Picture of the childcare environment as regards infant feeding.

Where does feeding typically occur?

Where do you get information about child care (Probe: family, radio, newspaper, church, neighbors, clinic, VHW etc.)? To get a general sense of the child care environment and where the mother gets important information with regards to childcare.

- Social norms

Introduction

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Question

Purpose

- Power to make child care decisions
- For each source probe how important it is to the mother.

Caregiving environment (SHINE interventions)

Now I would like to talk to you about the SHINE interventions. We would like to know your experiences within the SHINE project. Again there is no right or wrong answer, what we want to know are your experiences.

What were the most important messages you received from the VHW? We have this information from their trial arm allocation; this is to get a sense of the messages that stuck with the mother.

Were there messages that you received but you already knew? To get a sense of how women and their family members perceived the interventions
To also start to get a sense of how it influenced their caregiving practices.

Introduction

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Question

Purpose

Were there messages that you received that you disagreed with?

Did you talk to anyone about the messages received?

Who?

Do you remember what they thought about the messages?

What messages did you use in your care for [Index child] What? Why this information?

Did you encounter problems using these messages?

What?

- How did you deal with them

Were there messages that you received that you couldn't use? Why?

Introduction

Thank you for talking with me today. We are interested in learning more from the mothers about their experiences as mothers. We will ask you questions about your experience and opinions taking care of [Index child, I haven't had the opportunity yet to be a mother and hence have no experience with caregiving. I'm happy to talk to you and learn from your experiences. There are no right or wrong answers— you're the expert.

Question

Purpose

- Did you feel like you had the means and ability to follow the advice given
- How did that make you feel as a mother

Did you encounter any situations in your care for [Index child] that the messages from the VHW did not prepare you for?

How did you deal with them

Thinking about your experience with SHINE, Do you have any concerns about SHINE

- In your opinion how can it be improved?

What can make it easy for women to take up this information?

To understand experiences with the intervention

- Their opinion on the intervention

Challenges etc.

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Question

Purpose

- Probe which of these is the most important

What can make it difficult for women to take up this information?

- Probe which of these is the most important

When you think back to the visits and lessons that you received from your VHW since your pregnancy, how satisfied are you with these visits? Why?

To get a sense of the women's interactions with the VHWs

- Probe for the duration of the interaction
- Quality of interaction

Women's self evaluation

Thank you for all the responses. Your experiences are very important in our understanding of the SHINE project. Finally before I leave I would like to ask you to answer one last question.

Introduction

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Question

[Show picture of ladder]. If you think of this ladder as a measure of caregiving with the top being the BEST/IDEAL caregiver/mother and the bottom being the worst caregiver, where do you place yourself?

Purpose