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Improving food hygiene behaviours among child caregivers in rural community households of Malawi

By

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DOCTOR OF PHILOSOPHY

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Declaration

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Abstract

Globally, diarrheal disease accounts for over 90% of foodborne illness, with over 70% of this burden in Sub-Saharan Africa. However, traditional diarrheal prevention interventions focused on water, sanitation, and handwashing, with little integration of food hygiene. This thesis designed and implemented a theory-based complementary food hygiene intervention in rural Malawi and evaluated its impact on food hygiene behaviours.

Formative research and intervention development was grounded in the RANAS (Risk, Attitude, Norms, Ability and Self-regulation) Model and targeted five behaviours: cleaning of cooking and feeding utensils, safe utensil storage, reheating of left-over food, child self-feeding and handwashing with soap. The intervention was delivered for 9 months through village meetings in 800 household visits. Formative research indicated that risk, norms, ability and self-regulation factors were primary factors of the selected behaviours. Intervention was linked to Behaviour Change Techniques of the RANAS model. Villages were assigned to a control or intervention group and targeted caregivers of children aged five years and below. Intervention outcomes were measured using a before and after study with a control. Changes in food hygiene behaviours between baseline and follow-up data, and between the intervention and control groups were measured using ANOVA and t-test. Mediation models were used to uncover underlying mechanisms and effects of an intervention on changes in target behaviours.

At end-line, three behaviours showed a significant difference among intervention recipients: cleaning utensils with soap (*P*=0.000); safe utensil storage (*P*=0.000) and handwashing with

soap (*P*=0.000). For the three significant behaviours, psychosocial factors differed significantly between the intervention and control groups. Results showed that perceived risk, norm, ability and self-regulation factors (*P*=0.000) mediated the effect of the intervention on the significant behaviours among the intervention participants.

The study suggests that theory driven behaviour change initiatives using contextual and psychosocial factors effectively improved food hygiene behaviours in rural Malawi.

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List of Publications Stemming from this PhD Research

1. **Chidziwisano K**, Tilley E, Malolo R, Kumwenda S, Musaya J, Morse T. (2019). Risk Factors Associated with Feeding Children under 2 Years in Rural Malawi—A Formative Study. *Int J Environ Res Public Health*;16(12):2146. https://doi.org/10.3390/ijerph16122146

2. **Chidziwisano K**, Slekiene J, Kumwenda S, Mosler H-J, Morse T. (2019). Toward Complementary Food Hygiene Practices among Child Caregivers in Rural Malawi. *American Journal of Tropical Medicine and Hygiene*, Virginia. 101(2): 294–303. https://doi.org/10.4269/ajtmh.18-0639

3. **Chidziwisano, K.**; Tilley, E.; Morse, T. Self-Reported Versus Observed Measures: Validation of Child Caregiver Food Hygiene Practices in Rural Malawi. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4498. https://doi.org/10.3390/ijerph17124498

4. **Chidziwisano K**, Slekiene J, Mosler H-J, Morse T. (2020). Improving complementary food hygiene behaviours using the Risk, Attitude, Norms, Abilities and Self-regulation approach in rural Malawi. *American Journal of Tropical Medicine and Hygiene*, Virginia. AJTMH-19-0528. https://doi.org/10.4269/ajtmh.19-0528

List of other Publications related to this PhD Research where the Author is co-author

1. Morse T, **Chidziwisano K**, Tilley E, Malolo R, Kumwenda S, Musaya J, Cairncross S. (2019). Developing a Contextually Appropriate Integrated Hygiene Intervention to Achieve Sustained Reductions in Dirrhoeal Diseases. *Sustainability*. 2019;11(17):4656. https://doi.org/10.3390/su11174656

2. Torondel B, Balls E, Chisenga C, Kumwenda S, Okello E, Simiyu S, Morse T, Smith K, Mumma J, Banzi J, Harvey E, **Chidziwisano K**, Chipungu J, Grosskurth H, Beda A, Kapiga S, Estevesmills J, Cumming O, Cairncross S, Chirengi R. (2019). Experiences of capacity strengthening in sanitation and hygiene research in Africa and Asia: the SHARE Research Consortium. *Health Res Policy Sys 17, 77* (2019).https://doi.org/10.1186/s12961-019-0478-2

3. Morse, T.; Tilley, E.; **Chidziwisano, K**.; Malolo, R.; Musaya, J. (2020). Health Outcomes of an Integrated Behaviour-Centred Water, Sanitation, Hygiene and Food Safety Intervention–A Randomised before and after Trial. *Int. J. Environ. Res. Public Health*, *17*, 2648. https://doi.org/10.3390/ijerph17082648

4. Malolo, R.; Kumwenda, S.; **Chidziwisano, K.;** Kambala, S.; Morse, T. (2021). Social outcomes of a community-based Water, Sanitation and Hygiene intervention. *Journal of*

Water, Sanitation and Hygiene for Development washdev 2021264. https://doi.org/10.2166/washdev.2021.264

5. Panulo, M.; **Chidziwisano, K.**; Beattie, T.; Tilley, E.; Kuchande, S.; Kambala, S.; Morse, T. (2021). Process evaluation of the "Hygiene Family" intervention: A community – based Water, Sanitation and Hygiene project in rural Malawi *(In Draft)*.

List of Conferences

1. **Chidziwisano K.**, Slekiene J., Tilley E., Malolo R., and Morse T (2019). A combined WASH and complementary food hygiene intervention to reduce diarrhoeal disease in rural Malawi. *American society of Tropical medicine and Hygiene 2019 Annual conference, Maryland, USA.*

2. **Chidziwisano K.,** Slekiene J., and Morse T., (2019). Intervention study to improve food hygiene behaviours in rural households of Malawi. 2019 *UNC Water and Health conference: Where Science Meets Policy October 7-11, 2019, North Carolina, USA.*

3. **Chidziwisano K.,** Slekiene J., Kumwenda S., Mosler H., and Morse T., (2018). Towards complementary food hygiene practices among child caregivers: formative research in rural Malawi. *2018 UNC Water and Health: Where Science Meets Policy, North Carolina, USA.*

4. **Chidziwisano K.,** Kumwenda S., and Morse T., (2018). Determinants of complementary food hygiene practices of child caregivers in rural Malawi. *2018 Social and Behaviour Change Communication conference, Nusa Dua, Bali, Indonesia.*

5. **Chidziwisano K.,** and Morse T., (2018). Malawi Sanitation and Hygiene Applied Research for Equity (SHARE) Research Uptake. *41st WEDC International Conference, July 2018, Nakuru, Kenya.*

List of Awards

1. Shortlisted in the final round of 2021 Images of Research competition at the University of Strathclyde.

2. 2019 winner of the Images of Research: "Health and Wellbeing" category at the University of Strathclyde.

3. Recipient of the Bill and Melinda Gates Foundation award to present at the 2019 UNC – Water and Health Conference in North Carolina, USA.

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List of Abbreviations and Acronyms

ANOVA	Analysis of Variance
BCD	Behaviour Centred Design
BCT	Behaviour Change Technique
BCW	Behaviour Change Wheel
CCP	Critical Control Point
CHW	Community Health Workers
CFU	Colony Forming Unit
CI	Confidence Interval
CKI	Community Key Informant
CLTS	Community Led Total Sanitation
DALYs	Disability Adjusted Life Years
DFID	Department for International Development
EAWAG	Swiss Federal Institute of Aquatic Science and Technology
FAO	Food and Agriculture Organization
GoM	Government of Malawi
HACCP	Hazard Analysis Critical Control Point
HIC	High Income Countries
HSA	Health Surveillance Assistant
HWF	Hand Washing Facility
IBM – WASH	Integrated Behaviour Model for Water, Sanitation and Hygiene
JCE	Junior Certificate of Education
LMIC	Low and Middle Income Countries

LSHTM	London School of Hygiene and Tropical Medicine
MDGs	Millennium Development Goals
MGDS	Malawi Growth and Development Strategy
MoH	Ministry of Health
MoIWD	Ministry of Irrigation and Water Development
MSCE	Malawi School Certificate of Education
NASA	National Aeronautics and Space Agency
NGOs	Non – Governmental Organizations
NSHCU	National Sanitation and Hygiene Coordination Unit
ODF	Open Defecation Free
ODK	Open Data Kit
PACT	Pan – African Clinical Trials
RANAS	Risk, Attitude, Norms, Abilities and Self – Regulation
SDGs	Sustainable Development Goals
SHARE	Sanitation and Hygiene Applied Research for Equity
SUN	Scaling Up Nutrition
TA	Traditional Authority
UNICEF	United Nations Children Fund
USAID	United States Agency for International Development
VHC	Village Health Committee
WASH	Water, Sanitation and Hygiene
WASHTED	Water, Sanitation, Health and Technology Development
WHO	World Health Organization

Definition of terms

Behaviour	The performance of a particular action. This includes both execution of a healthy and unhealthy behaviours.
Behaviour change technique	Are the actual activities in an intervention to address behavioural factors (i.e. smallest active components of a behaviour change intervention). Thus, they form the intervention strategy of a behaviour change campaign.
Behaviour factors	Behavioral factors are perceptions, thoughts, feelings, and beliefs which influence the practice of a behavior.
Child caregiver	Any household member, including parents who are responsible for daily care of young children
Cluster	A group of child caregivers with children aged five years and below living within the same village and community.
Communication channels	The methods of delivery an intervention in a behaviour change campaign/promotion
Complementary food	Any food or liquid other than breast milk given to young children.
Contextual factors	Are individual, setting and environmental determinants that can influence behaviour change and adoption of new technologies
Dish rack	An elevated place in form of a rack for holding kitchen utensils as dishwater drains off of them. This place is also used for storing utensils at the household.
Donor partner	Mainly international stakeholders that provide financial and technical support to Malawi.
F diagram	The diagram that shows five key faecal oral transmission of diarrhoeal pathogens
Food hygiene	The measures and conditions necessary to control hazards and to ensure fitness for human consumption of a foodstuff taking into account its intended use'.9 EU food law is science based.
Formative research	Research conducted during the development of a program to help decide on and describe the target audience, understand the factors which influence their behavior, and determine the best ways to reach them. It looks at behaviors, attitudes and

	practices of target groups, involves exploring behavioral determinants, and uses a myriad of methods to collect data. Formative research may be used to complement existing epidemiological and behavioral data to assist in program planning and design.
Handwashing facility	A facility that is meant for self - cleaning/washing of hands and has adequate supply of running clean water and soap.
Handwashing practice	Refers to the act of cleaning/washing of hands using running water and soap at critical times to enhance the removal of water and sanitation related disease-causing microorganisms. The critical times advanced and advocated for hand washing in this Thesis include but not limited to after defecation; after handling infant's faeces or soiled nappies; before preparing food; and before eating.
Hygiene	Conditions and practices that serve to promote or preserve health at the household.
Hygienic Intervention	The systematic process of assessment and planning and implementation employed to remediate hygiene related problem.
Household	A group of persons who normally live and eat together.
Sanitation	Refers to the principles and practices relating to the collection, removal and hygienic disposal or recycling of human excreta, solid waste and wastewater, as they impact upon users, operators and the environment. The system or facility should be acceptable and affordable to the user in addition to being structurally safe and offering privacy. At the household level this includes human waste, kitchen rubbish, water from cooking, bathing and washing clothes and household utensils, and any other discarded items.
Psychosocial factors	Refer to psychological processes interacting with social contextual forces which shape an individual's behaviour.

Chapter – 1

Background

1.1 Rationale

Despite substantial resource being invested in Low and Middle Income Countries (LMICs) to address challenges associated with poor Water, Sanitation and Hygiene (WASH), preventable diarrhoeal diseases remain a significant cause of death, especially among children aged five years and below (WHO, 2017). Amongst other factors, food contaminated with pathogens has been strongly linked to childhood diarrhoea. Thus, food hygiene practices are a key factor which significantly contributes to child survival during the first 1000 days of life (WHO, 2013b). However, food hygiene has received little attention in programmes and efforts to improve child health in these low income settings. This thesis provides a detailed understanding of the current situation pertaining to food hygiene practices in LMIC, how they may be affecting the health of children under five, and suggest interventions to address the identified gaps.

This chapter provides background on food hygiene from a global context, and the specific existing gaps in rural households of Malawi.

1.2 Introduction

Diarrhoeal disease remains one of the leading causes of morbidity and mortality in children under the age of five years globally, with approximately 424,000 deaths annually (WHO, 2017). It accounts for 9% of all deaths among children aged 5 years and below in LMICs (Carvajal-Vélez et al., 2016). Despite UNICEF reports about a decline in childhood diarrhoea globally (Alkema & You, 2012), it still remains common among children aged 6 – 24 months in LMICs, which presents a public health threat given the limited financial, medical and human resources, and poor resource management in these settings (Fischer Walker et al., 2013; Liu et al., 2015). This requires further attention including childhood diarrhoea prevention strategies appropriate for these low income settings.

As shown in Figure 1, primary sources of direct and indirect contamination of a new host have been outlined in the faecal oral disease transmission route, commonly depicted as the F-diagram for decades (Penakalapati et al., 2017; Wagner & Lanoix, 1958), highlighting the key transmission routes for pathogenic organisms. It clearly shows how faecal matter (human and animal) through fluids, fields, flies and fingers (the four "Fs") can contaminate food before transmitting pathogens to a susceptible host. Research undertaken in low income countries (Boehm et al., 2016; Kamm et al., 2014; Kwong et al., 2016; Teunis et al., 2016; Wodnik et al., 2018) has expanded on the F-diagram to better illustrate the links between under-five behaviours, daily activities, and faecal exposure. Furthermore, several studies have now reported the significance of child play areas, mouthing, geophagia, animal contact and water as potential sources of diarrhoeal disease transmission within these settings (Desai et al., 2015; Luby et al., 2018a; Majo et al., 2013; Mbuya et al., 2015; Null et al., 2018).

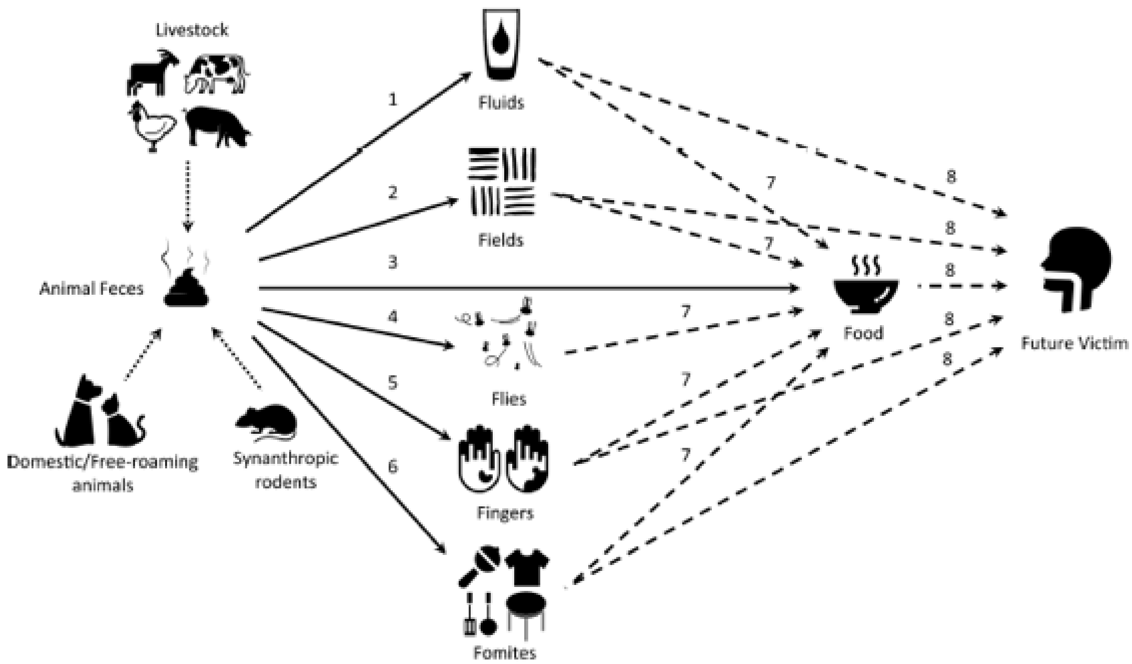

Figure 1: The F - diagram of faecal oral transmission route of diarrhoeal pathogens (Penakalapati et al., 2017; Wagner & Lanoix, 1958)

The WHO has continued to emphasize not only the importance of effective treatment, but also the integral role that prevention plays in the control of diarrhoeal diseases, highlighting priorities such as: rotavirus and measles vaccinations; promotion of early and exclusive breastfeeding and vitamin A supplementation; promotion of handwashing with soap; improved water supply quantity and quality; and community-wide sanitation promotion (Unicef/WHO, 2009). Despite the fact that these types of WASH interventions are generally cost effective (Unicef/WHO, 2009), there has been little progress in achieving implementation at scale; less than 5% of the population of Sub Saharan Africa have access to combined improved water, sanitation, and hygiene, as described by the Sustainable Development Goal indicators (i.e. Goal 6: “clean water and sanitation) (Roche et al., 2017). This shows that progress in reducing diarrhoeal disease through various simple technological, social and financial interventions has been elusive (Bartram & Cairncross, 2010; Wolf et al., 2014). Relatedly, attempts to model the complex mechanisms that potentially link poor sanitation and hygiene to diarrhoeal disease, enteric enteropathy, under nutrition, and child development, highlight the challenges of understanding the myriad of environmental transmission routes and sources of contamination, which may contribute to diarrhoeal and other related diseases. Previous WASH related attempts to reduce diarrhoea have emphasized water quality, improved sanitation and hand hygiene promotion with little attention to other prevention strategies such as household food hygiene interventions (Curtis et al., 2011). The contribution of food in the transmission of diarrhoeal disease has been clearly outlined by a 2015 WHO report, which attributed 70% of the burden of foodborne disease occurring in sub-Saharan African and South East Asia, with 40% affecting children under the age of five (WHO, 2015d).

Studies have highlighted the important role of food hygiene in diarrhoeal disease prevention, a key but often neglected area of the F-diagram. Significant numbers of pathogens have been isolated in complementary food (i.e. foods which supplement breast milk) in Sub-Saharan Africa, Bangladesh and Peru (Motarjemi et al., 1993; Woldt & Moy, 2015). Such contamination is associated with prolonged food storage at high ambient temperature, seasonality, and unclean utensils (Barrell & Rowland, 1979; Black et al., 1982; Michanie et al., 1987; Molbak et al., 1989; Motarjemi et al., 1993; Pickering et al., 2012). In addition, studies have reported significant associations between diarrhoeal disease and lack of a kitchen, kitchen cleanliness, handwashing at critical times, feeding practices, waste disposal and storage of food on the floor (Feachem & Koblinsky, 1983; Gorter et al., 1998; Maung U et al., 1992; Unicef/WHO, 2009; Vu Nguyen et al., 2006). Among other factors, post-cooking activities such as improper handling of kitchen utensils and poor handwashing practices are risk factors that have been associated with diarrhoea-causing pathogens in food in Malawi (Taulo et al., 2008, 2009).

However, the studies by Taulo et al (2008 and 2009) focused on microbiological assessment of the food and associated utensils without developing an intervention to improve food hygiene behaviours at household level.

Despite the prevalence of foodborne disease in LMICs, little effort has been made to understand and improve food hygiene practices in urban and rural household settings. Improving food hygiene behaviours is important for the promotion of child health programmes (e.g. nutrition programmes) since complementary feeding and WASH have been associated with a high risk of growth failure (Lin et al., 2013; Merchant et al., 2003; Ngure, 2012; Victora et al., 2010). Nevertheless, there has been less emphasis on integrating food hygiene in nutrition programming (Dodos et al., 2017). Previous research focused much on measuring microbial contamination in food with little attention to the development of tailor made food hygiene behaviour change interventions (Ehiri et al., 2001a; Imong et al., 1995a; Iroegbu et al., 2000; Schmitt et al., 1997; Taulo et al., 2008, 2009). Where research has developed and tested food hygiene behaviour change interventions, these have been focused on increasing the level of knowledge and the provision of WASH infrastructure, but did not address psychosocial factors that are integral to the performance of a behaviour (Islam et al., 2013; Monte et al., 1997; Sheth & Obrah, 2004; Touré et al., 2013). It has been demonstrated that access to knowledge alone does not achieve sustained hygiene behaviour change (Curtis et al., 2011).

To achieve sustained behaviour change, it is essential to consider the effects and impact of all personal, social, environmental, and psychosocial factors that directly and indirectly relate to hygiene practices, including the structural and socio-economic barriers that household members may face (Mosler, 2012). Models to promote positive, sustained behaviour change in the WASH sector, including household food hygiene interventions, must therefore have a strong element of human psychology to support knowledge and technological based interventions (Biran et al., 2014b; Curtis et al., 2011). Within the WASH sector, several models, such as Risks, Attitudes, Norms, Abilities, and Self-Regulation (RANAS) (Mosler, 2012), Behaviour Centred Design (BCD) (Aunger & Curtis, 2016), and SaniFOAM (Devine, 2009) have been developed, and shown to achieve this. For example, recent studies conducted in low income countries have demonstrated the potential impact of individual training, follow-up and participatory approaches (with hazard analysis principles) on the safety of domestically produced complementary foods (Gautam et al., 2017a; Islam et al., 2013; Manjang et al., 2018; Touré et al., 2013). However, these studies did not reveal which psychosocial factors changed because of the intervention, and were therefore responsible for changing the targeted behaviours. In addition, the studies were of a small (pilot) scale, with limited duration and sample size, and with a focus on homogenous populations, intensive training and education.

1.3 Significance of a food hygiene study in Malawi

As one of the poorest countries in the world (World Bank, 2019c), Malawi has a high prevalence of diarrhoeal disease among children under the age of five years, reported at 22% in 2016, an increase from the 17.5% reported in 2010 (Government of Malawi, 2016). It should be mentioned that the prevalence of childhood diarrhoea in Malawi increases to over 40% when children are between 6 – 18 months old (Government of Malawi, 2016); which could be directly linked to complementary foods and geophagy. This high prevalence of childhood diarrhoea could be one of the contributing factors to the high under-five mortality rate (62 deaths per 1000 births; Figure 2) experienced in Malawi (Government of Malawi, 2016). Amongst other factors, such as respiratory infections and malaria, inadequate access to sanitation and hygiene services contributes to such a high childhood mortality rate. For instance, improved sanitation coverage remains low at 52%, with 6% of the population still practicing open defaecation (Government of Malawi, 2019). Furthermore, only 19.5% of households have handwashing facilities, with only 10.7% of these facilities having soap and water (Government of Malawi, 2016). Coverage of safe water is high (85% in rural and 98% in urban areas) in Malawi (Government of Malawi, 2016). However, WHO/UNICEF Joint Monitoring reports that 69%, 20%, 9% and 2% in Malawi access basic, limited, unimproved and surface water respectively (WHO/Unicef, 2019).[1] Further, reports have indicated compromised water quality at household level due to poor transportation and storage, since the majority of Malawians in rural areas (72%) access their water for domestic use from a communal source (mostly boreholes), and household water treatment is rare (30%) (Government of Malawi, 2016).

[1] **Basic**: Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing
Limited: Drinking water from an improved source where collection time exceeds over 30 minutes for a roundtrip to collect water, including queuing
Unimproved: Drinking water from an unprotected dug well or unprotected spring
Surface water (No service): Drinking water collected directly from a river, dam, lake, pond, stream, canal or irrigation channel

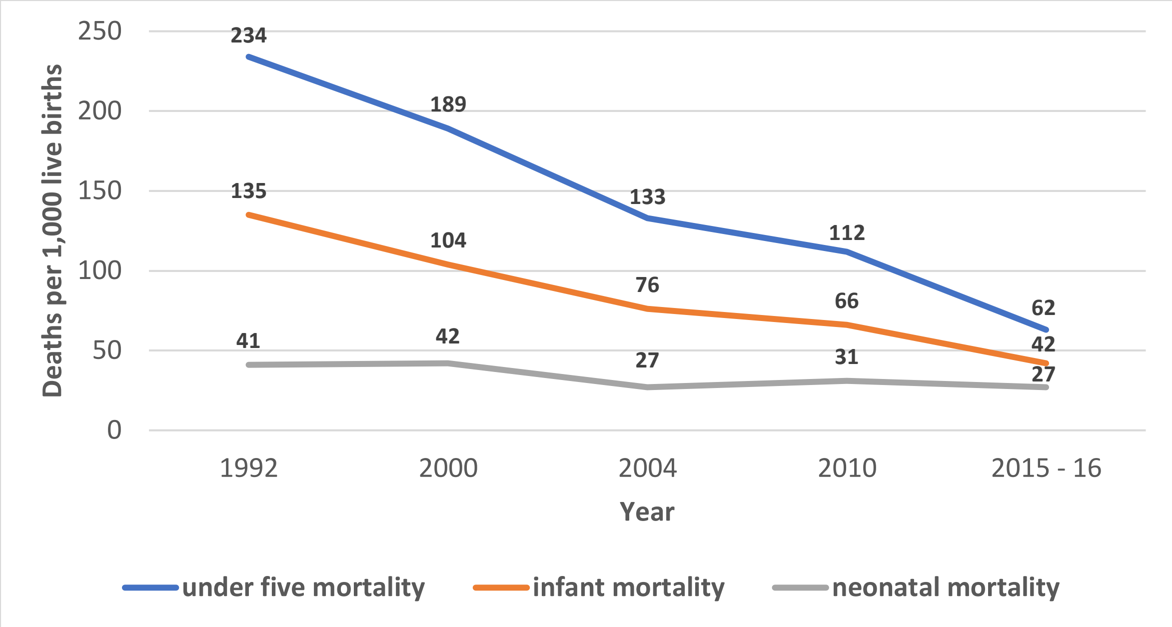

Figure 2: Trends in early childhood mortality rates in Malawi (Government of Malawi, 2016)

Despite that the majority of children (61%) are exclusively breastfed during their first six months of life, childhood malnutrition still remains high (Government of Malawi, 2016). For instance, stunting is at 37%, wasting at 3%, and underweight among children aged five years and below is at 12% (Figure 3). In addition, only 8% of the children aged 6-23 months meet the minimum acceptable dietary standards.

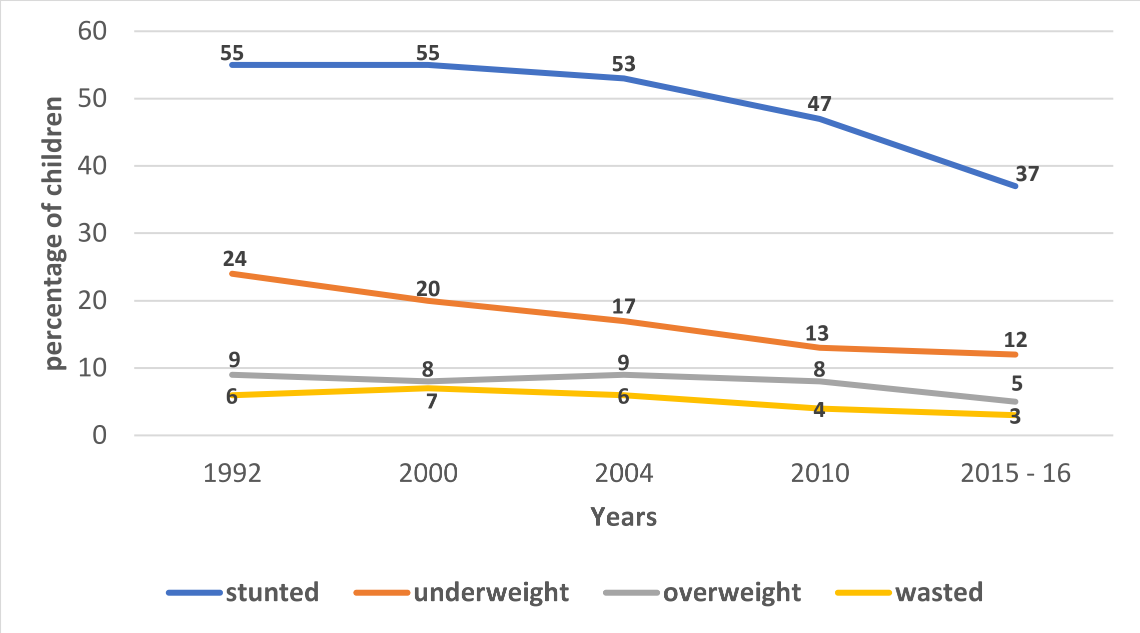

Figure 3: Trends in nutritional status of children aged five years and below in Malawi (Government of Malawi, 2016)

The Government of Malawi in collaboration with its development partners such as UNICEF and USAID have implemented a number of programmes to improve child health. For instance, food supplementation such as 'Scaling Up Nutrition' (SUN) and WASH improvement strategies such as 'Community Led Total Sanitation' (CLTS) and 'Safe Water Supply' have been given a priority to promote child nutrition and prevent diarrhoeal diseases (Government of Malawi, 2018c; Phiri, 2016). Despite international efforts to reduce food contamination at the point of consumption, as a critical component of public health interventions, food hygiene promotion activities have been poorly prioritized in Malawi. For instance, the current 'National Multi-sector Nutrition Policy and Strategic Plan' and 'National Sanitation Policy' have not emphasized the need to promote food hygiene behaviours at household level (Government of Malawi, 2006, 2018a). In addition, little research on food hygiene has been conducted in Malawi, and those undertaken mostly focused on the identification of critical control points, without designing and testing interventions, or taking into consideration necessary behaviour change opportunities (Taulo et al., 2008, 2009). More evidence is needed on optimal intervention design and delivery targeting vulnerable groups in LMICs, the barriers and opportunities to effectively improve food hygiene at the household level, and as a result reduce enteric infections in high burden populations. The WHO has outlined five key practices to reduce microbiological contamination in the household environment: handwashing with soap; separating raw and cooked foods; cooking food thoroughly; storing food at safe temperatures; and using safe water and raw materials (WHO, 2014). However, evidence of intervention effectiveness, barriers to improved practices, and health impact is limited. This research is intended to serve as a catalyst for effective, context specific food hygiene interventions to promote food hygiene behaviours in LMICs including Malawi.

1.4 Aim and objectives

1.4.1 Study aim

The main aim of this study was to design and test food hygiene behaviour change intervention using the RANAS (Risk, Attitude, Norms, Ability and Self – regulation) approach to behaviour change, with the purpose of understanding the efficacy of the intervention in improving food hygiene behaviours among child caregivers with children aged five years and below in rural households of Malawi.

Specific objectives

1. To identify research and programme gaps in food hygiene at household level in LMIC. Thus, through literature review, this objective provides an overview of the existing critical control points and actions in preventing foodborne illnesses at household level. In

addition, previous food hygiene research intervention trials in WASH behaviour change theories were reviewed. The following research questions were included under Objective 1 (presented in

2.

3.

4. # Chapter 2):

a) What is the prevalence of foodborne disease globally?

b) What are the research gaps associated with existing critical control points for the prevention of foodborne disease at household level in LMICs?

c) What are the existing research gaps associated with household food hygiene interventions in LMICs?

d) Which WASH behaviour change theory/approach is suitable for a food hygiene behaviour change intervention trial in rural Malawi?

5. To identify and evaluate current food hygiene practices among child caregivers with children aged five years and below in rural households of Malawi.

Thus, this research objective identified household food hygiene practices through six months of formative research applying a mixed methods approach in 320 households within rural setting (presented in Chapter 3). Relevant research questions here included:

a) What are the current food hygiene practices amongst household members in the targeted households?

b) Which food hygiene practices are critical to the prevention of foodborne diseases including diarrhoea among children aged five years and below?

6. To investigate and interpret the behavioural factors (psychosocial and contextual) associated with food hygiene practices (identified in objective 2) among child caregivers with children aged five years and below in rural households of Malawi (presented in Chapter 3).

   The purpose of this objective was to uncover which of the behavioural factors underlying food hygiene practices identified in objective 2 were relevant to the undesired behaviours of those who did not perform the recommended targeted behaviours (i.e. the non – doers). This objective provided the mechanisms underlying undesirable behaviours, enabling the development of interventions tailored specifically to overcome such undesired behaviour. The research questions included:

   a) What are the contextual factors of the food hygiene behaviours?

   b) What are the psychosocial factors of the food hygiene behaviours?

7. To develop and implement a food hygiene intervention targeting child caregivers with children aged five years and below in rural households of Malawi (presented in Chapter 4).

   Thus, with information from Objectives 2 and 3 (Chapter 3), a tailor made food hygiene intervention was developed over a period of three months. Behaviour change techniques (BCTs) of the RANAS model guided the development of the intervention activities, which corresponded with the identified behavioural factors. This initial trial period was followed by implementation of the designed food hygiene intervention for a period of 9 months to test its effectiveness. This objective included the following research question:

a) How could the proposed food hygiene intervention be implemented to deliver the intended results?

8. To evaluate the effectiveness of the behaviour change intervention on food hygiene practices among child caregivers with children aged five years and below in rural households of Malawi after nine months of intervention implementation (presented in Chapter – **5**). This objective aimed to assess if food hygiene behaviour change had happened among the child caregivers receiving the intervention. It also aimed to reveal the mechanisms underlying changes in food hygiene behaviours following the intervention. Thus, it ascertained whether the behaviour change intervention influenced changes in the behavioural factors, and whether the intervention indirectly influenced the targeted food hygiene behaviours. The following research questions were addressed by this objective:
    a) Did target behaviours change because of the intervention?
    b) Which contextual and psychosocial factors changed between intervention and control groups, and how did these vary?
    c) Which psychosocial factors changed because of the intervention and therefore mediated the change in behaviour?

1.5 Overarching research project and structure of the research team

This PhD research was part of a larger project implemented by the Sanitation, Hygiene Applied Research for Equity (SHARE) consortium consisting of researchers from the University of Malawi (The Polytechnic - WASHTED Centre) and the University of Strathclyde in collaboration with the London School of Hygiene and Tropical Medicine (LSHTM), with funding from the UK Aid (Foreign, Commonwealth and Development Office – FCDO). The overall aim of the SHARE research project (The Hygienic Family) in Malawi was to determine the relative effectiveness of food hygiene and WASH interventions in preventing diarrhoeal disease in children under five years old in rural households of Malawi. The overall research programme contained several planned outcomes:

Primary outcome:

- childhood diarrhoea reduction in the intervention households

Secondary outcome:

- Improved food hygiene behaviours among the child caregivers in the intervention households
- Reduction in respiratory infections among the children in the intervention households

The research aim and objectives of this thesis (defined above) were focused on the secondary outcome of improved food hygiene behaviours among child caregivers in the intervention households. As a PhD candidate, I was responsible for the behavioural component of the research. Consequently, I led the research team highlighted in Figure 4 in conducting formative research, designing and delivering the intervention, and in evaluating the intervention trial. The team consisted of three group coordinators who were responsible for the implementation and fidelity of all research related activities in the intervention and control areas.

A team of five female observers (BSc holders in Social Sciences (n = 1) and Environmental Health (n = 4)) were trained for five days to conduct checklist and structured observations at baseline and follow up data collection points. Similarly, household surveys were conducted by 10 well-trained BSc holders who were experienced research assistants. Both data collection teams were fluent in the local language (Chichewa). The community coordinators (n = 40) who facilitated the cluster meetings and conducted household visits were drawn from the study communities. Some of them were already serving their communities as community health volunteers through existing structures such as Village Health Committees (VHC). In addition, the coordinators were holders of the Malawi School Certificate of Education (MSCE) which is an equivalent to the English General Certificate of Education "O" level. The research project team also included two laboratory technicians who analyzed the microbiological food samples collected during formative research.

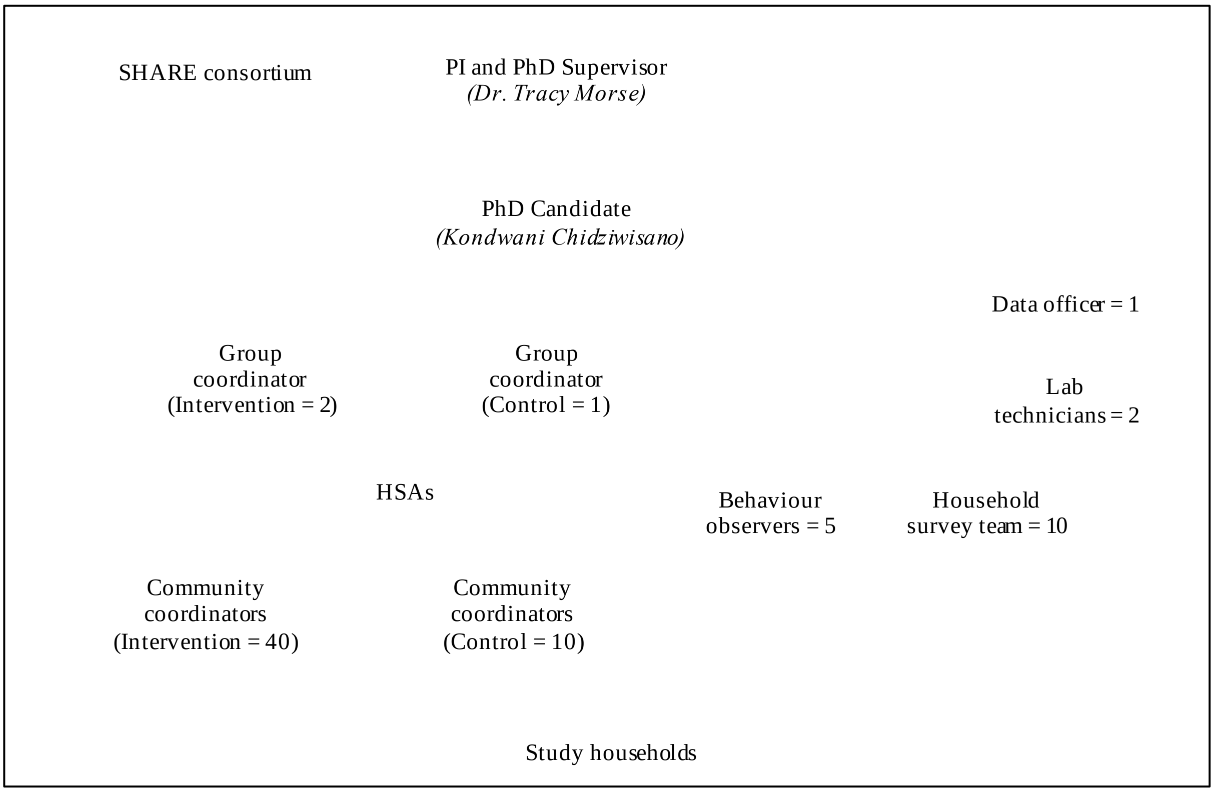

Figure 4: Structure of the research team

Note: SHARE: Sanitation and Hygiene Applied Research for Equity, PI: Principal investigator, HSA: Health Surveillance Assistant, Lab technician: Laboratory technician

Chapter 2

Literature review

2.1 Rationale

This chapter provides an overview of the need and relevance of food hygiene including burden of foodborne diseases, including transmission of pathogens via food, globally, starting with developed countries. For LMICs, it further reviews food hygiene studies, including intervention trials that have been conducted at household level. Thus, this section identifies important knowledge gaps and provides available evidence about food hygiene interventions at household level. WASH behaviour change theories are then introduced, particularly as a solution to current hygiene behaviours among rural household communities. A range of behaviour change models are discussed, before the RANAS model of behaviour change as a method of communicating the food hygiene behaviour change intervention in this study is presented, including its relevance to positively elicit WASH behaviour change.

2.2 The need for food hygiene

For a long time, poor hygiene and sanitation practices have been well known as critical contributing factors to the causation of childhood diarrhoea and malnutrition. Measures to improve WASH, as well as food supplementation, including exclusive breastfeeding, have been put in place to prevent pathogens from causing such diseases (Clasen et al., 2015; Dangour et al., 2013; Nizame et al., 2013). However, there have been few interventions in LMICs to reduce bacterial contamination in food; a key component of the F – diagram (Figure *1*) (Penakalapati, 2017). Lack of such food hygiene interventions is linked to the fact that WASH stakeholders have emphasized that contaminated water is the major transmission route of diarrhoeal diseases at household level (Curtis et al., 2011). This relates to what has been reported previously; that over 90% of diarrhoea in children is associated with poor sanitation, lack of safe water, and inadequate personal hygiene (Jamison et al., 2006). As such, activities to promote safe water supply are highly prioritized in developing countries. In addition, programme implementers are advised to focus on safe disposal of human faeces and handwashing with soap after latrine use (Curtis et al., 2011). However, in 1989, a detailed study was conducted which provided noticeable evidence that childhood diarrhoea in LMICs could also be linked to contaminated food (Ersey & Feachem, 1989). The authors suggested the need to design low cost food hygiene interventions to promote household food hygiene behaviours. Although this gained little traction at the time, it was subsequently documented that food could be more important than water in the transmission of diarrhoeal pathogens in low income countries (Lanata, 2003), and a study in India showed that coliforms were absent in drinking water, while significant concentrations of the same were identified in food meant for children. As such, high diarrhoeal disease prevalence in under-fives may well be attributed to contaminated food (Sheth et al., 2000).

2.3 Relevance of complementary food hygiene to child nutrition

Malnutrition continues to claim many lives of children under five years of age. Almost half of the deaths among these children is due to undernutrition (i.e. deficiency of nutrients) (Unicef, 2017). Globally, the growth of 21.9% of children aged five years and below is stunted, which is a strong indicator of chronic malnutrition (WHO, 2019); it has been estimated that undernutrition in form of stunting and wasting affects 144 million (21.3%) and 47 million (6.9%) children under five years of age, respectively (Unicef et al., 2020). Further, evidence has shown that malnutrition is highest in low income regions of the world which include sub Saharan Africa and south Asia, and is among the contributors to the vicious cycle of poverty and disease in these areas (De Onis et al., 2015).

Foodborne illness can lead to different health complications such as watery and bloody diarrhoea, meningitis, chronic renal, cardiovascular, immune and respiratory diseases (Archer, 1984; Archer & Young, 1988; Saunders, 1984). Additionally, nutritional deficiencies and disorders are known to be a major outcome of foodborne disease. Infectious diseases affect a child's food intake and, with associated loss of nutrients from vomiting, diarrhoea and malabsorption, lead to under-nutrition which affects physical and cognitive development of children (Figure 5). As a result the child becomes vulnerable to other infections, and thus finds itself in the vicious cycle of malnutrition and infection (Motarjemi et al., 1994a).

Food contamination

Disease:
Incidence
Severity
Duration

Weight loss
Growth faltering
Lowered immunity
Mucosal damage

Appetite loss
Nutrient loss
Malabsorption
Altered metabolism

Inadequate
dietary intake

Food shortage

Figure 5: Malnutrition and the infection cycle (Tomkins & Watson, 1989)

Undernutrition is directly linked to inadequate dietary intake and ill health, factors which are associated with contaminated water, poor sanitation and hygiene, and faecally contaminated environments, and can lead to enteric dysfunction and infestations (e.g. soil mediated helminths) which minimize absorption of essential nutrients (Halcrow et al., 2017). To this end, it has been emphasized that an integrated approach is required to halt the burden of undernutrition where nutrition specific interventions (e.g. nutrient supplementation) should be integrated with nutrition sensitive interventions, such as WASH interventions, including complementary food hygiene promotion initiatives (Jannat et al., 2019; WHO, 2015a). Consequently, the WHO and key stakeholders made a commitment to apply an integrated approach in implementing WASH and nutrition programmes (WHO, 2015a).

Breast milk is considered safe food and highly nutritious for children below 6 months of age (Motarjemi et al., 1994a). Exclusive breastfeeding is recommended by the WHO for the first 6 months of life because it protects infants from pathogens that could be found in food and water (Kramer & Kakuma, 2012). After 6 months, a child's diet needs to be supplemented with other foods, i.e. complementary foods, in addition to breastfeeding. It is at this point that the child becomes potentially exposed to different disease-causing organisms including those responsible for diarrhoea (Motarjemi, 2000). For various reasons, many infants in LMICs are introduced to complementary food before they reach 6 months which increases their risk of exposure to pathogens. Globally, only 39% of infants less than 6 months have been reported to be exclusively breastfed (WHO, 2013a). Several studies have reported increased incidence of diarrhoea when children are introduced to complementary food because of unhygienic food preparation practices (Ehiri et al., 2001a; Motarjemi et al., 1994a).

2.4 The prevalence of foodborne diseases

Foodborne diseases contribute to high morbidity and mortality every year and impede socio-economic development worldwide; these diseases are caused by infectious agents (e.g. bacteria, virus and parasites) and food contaminated by chemicals. For instance, fenugreek sprouts contaminated with *Escherichia coli* (0157) caused an outbreak in Germany that affected 386 people and caused 54 deaths in 2011 (Frank et al., 2011). Similarly, in 2006, infant milk formula contaminated with melamine in China caused 294,000 cases of food poisoning, with 50,000 hospitalization and 6 deaths (Ingelfinger, 2008). In an effort to improve policies regarding foodborne disease, the WHO launched an initiative to estimate the global burden of foodborne disease (WHO, 2006). In 2010, under this initiative, the WHO reported that 31 foodborne hazards (Table 1), the majority of which were diarrhoeal disease agents (mainly norovirus and *Campylobacter* spp.), caused 600 million foodborne disease cases (95% uncertainty interval of 420 – 960) and 420,000 deaths globally (95% uncertainty interval of 310,000 - 600,000) (WHO, 2015b). Specifically, foodborne diarrhoeal disease agents caused 230,000 deaths (95% uncertainty interval of 160,000 – 320,000), mostly from non–typhoidal *Salmonella enterica* (NTS) and *Salmonella typhi*. It was further reported that 18 million DALYs (Disability Adjusted Life Year) (95% uncertainty interval of 12 – 25) have been attributed to foodborne diarrhoeal disease globally (WHO, 2015b).

Table 1: Foodborne hazards identified by the World Health Organization (WHO, 2015b)

Type and number of foodborne hazards	Name of specific foodborne hazards	Name of specific foodborne hazards
11 diarrhoeal disease agents	1 virus	*Norovirus*
	7 bacteria	*Shigella* spp *Enterotoxigenic E. coli* *Shiga toxin-producing E. coli* *Enteropathogenic E. coli* *Salmonella typhi* *Non – typhoidal Salmonella enterica*
	3 protozoa	*Giardia* spp *Entamoeba histolytica* *Taxoplasma ghondii*
7 invasive infectious disease agents	1 virus	Hepatitis A
	5 bacteria	*Vibrio cholerae* *Campylobacter* spp *Mycobacterium bovis* *Brucella* spp *Listeria monocytogenes*
	1 protozoon	*Cryptosporidium* spp
10 helminth agents	-	*Taenia solium* *Paragonimus* spp *Ascaris* spp *Clonorchis* spp *Echinococcus multilocularis*

		Opisothorcis spp Intestinal flukes *Fasciola* spp *Echinococcus granulosus* *Trichinella* spp
3 chemical agents	-	Dioxins Aflatoxin Cassava cyanide

The WHO's initiative to estimate the global burden of all foodborne disease in 2010 reported that the burden of foodborne diseases was 33 million DALYs, which has been found to be of a similar order of magnitude as the 'big three' infectious diseases; HIV/ AIDS, malaria and tuberculosis at 92, 55 and 44 million DALYs, respectively. As mentioned above, 18 million DALYs (54%) of the foodborne burden was attributed to diarrhoeal disease agents, mostly non typhoidal *Salmonella enterica* which caused 4 million DALYs (Havelaar et al., 2015). It was further reported that norovirus, *Campylobacter* spp., Enteropathogenic *E. coli* (EPEC), Enterotoxigenic *E. coli* (ETEC), *Vibrio cholerae* and *Shigella spp*., each contributed a burden of 1 – 3 million DALYs (Figure 6). The WHO (2015b) indicated that 40% of children under 5 years of age were heavily burdened by foodborne diseases, despite representing only 9% of the global population.

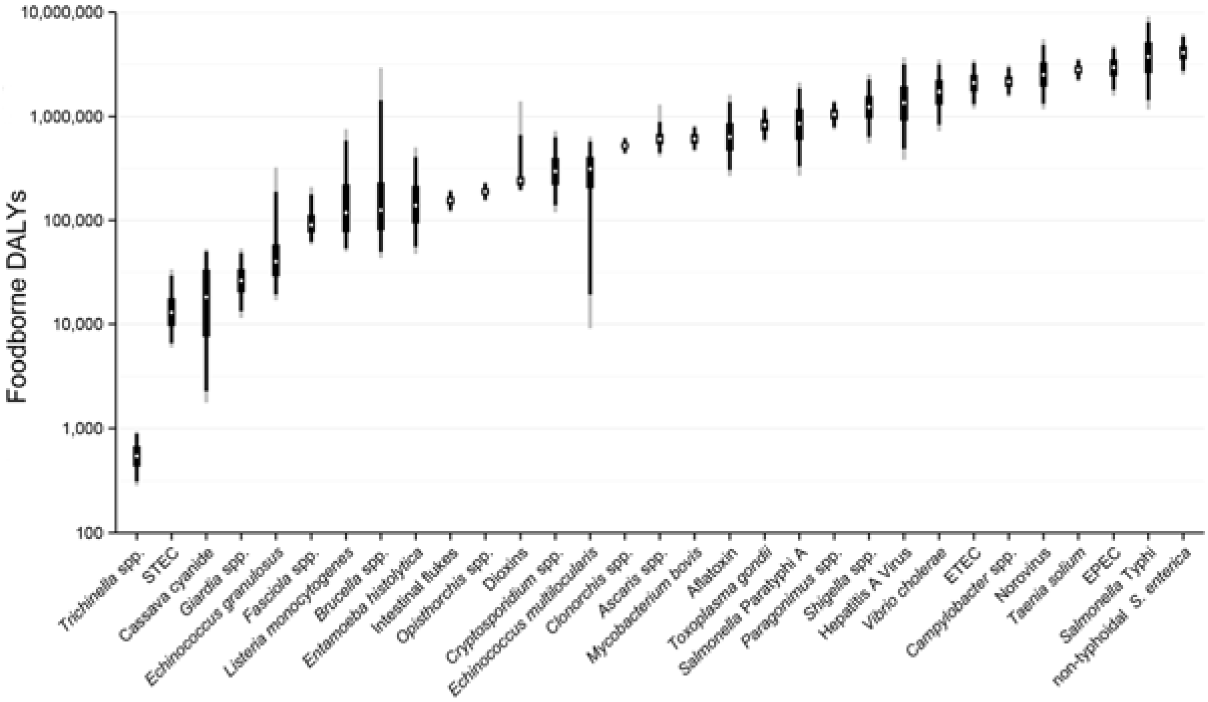

Figure 6: Ranking of foodborne hazards globally for 2010, expressed as Disability Adjusted Life Years (Havelaar et al., 2015)

Note: White dots indicate the median burden, black boxes the inter-quartile range (50% UI), black lines the 5 and 95 percentiles (90%UI) and grey lines the 2.5 and 97.5 percentiles (95% UI). Note the y-axis is on a logarithmic scale. Abbreviations: EPEC: Enteropathogenic Escherichia coli; ETEC: Enterotoxigenic E. coli; STEC: Shiga toxin-producing E. coli

Considerable variation in foodborne disease burden have been observed in different regions of the world (Figure 7). The African regions had the highest burden (2500 DALYs per 100 000 population) followed by South East Asia (1400 DALYs per 100 000 population); the Eastern Mediterranean region had 570 DALYs per 100 000 population, while the lowest burden was noted in North American and European regions (ranging from 35 to 50 DALYs per 100 000 population) (WHO, 2015b). Such burden experienced in the regions of the world was from different individual hazards, though mostly from diarrhoeal disease agents followed by invasive infectious disease agents. For instance, in the African region, the burden was from diarrhoeal disease agents (i.e. non-typhoidal *Salmonella enterica* including invasive salmonellosis, enteropathogenic *Escherichia coli*, Enterotoxigenic *Escherichia coli* and *Vibrio cholerae*). Similarly diarrhoeal disease agents mostly enteropathogenic *E. coli*, norovirus, non-typhoidal *Salmonella enterica*, Enterotoxigenic *E. coli* and *Campylobacter* spp. greatly contributed to foodborne disease burden in South East Asian region. In the American and European regions, *Campylobacter* spp., norovirus and non-typhoidal *S. enterica* agents were the main causes of foodborne disease burden (Havelaar et al., 2015).

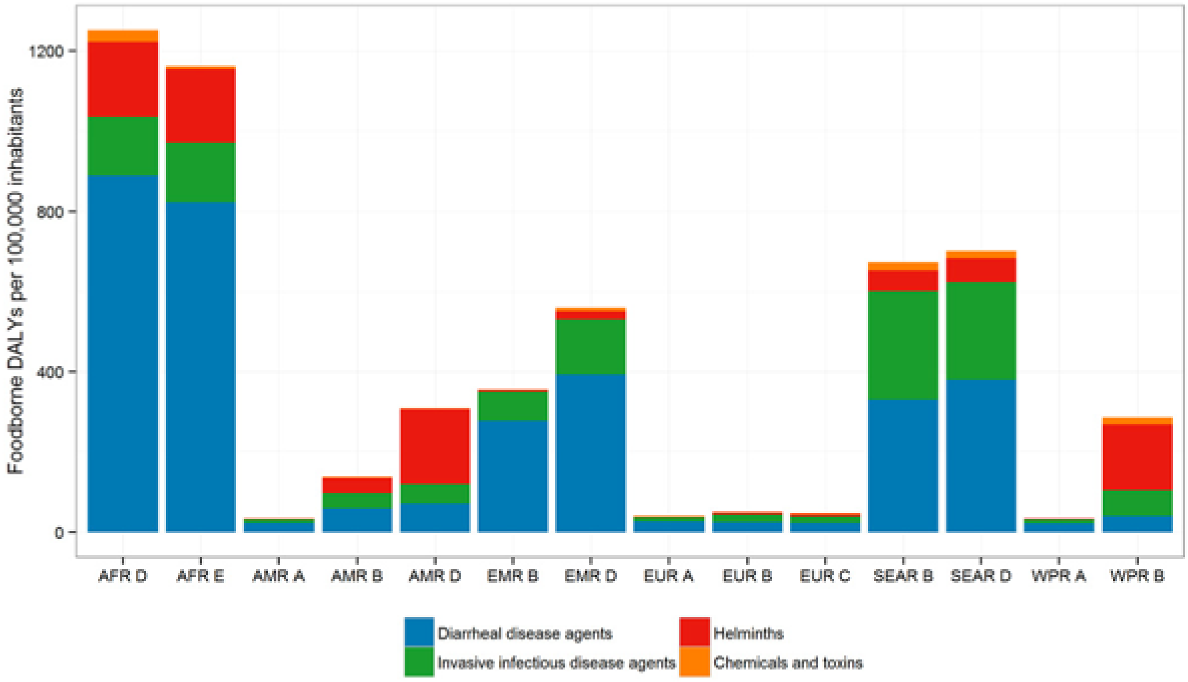

Figure 7: The global burden of foodborne disease (DALYS per 100,000 population) by hazard groups and by sub-region for 2010. Refer to Appendix 4**: WHO sub – regions in detail (Source: (WHO, 2015c)** for specific countries for each sub – region (Havelaar et al., 2015)

As shown in Figure 8, the burden of diarrhoeal disease has been on the decline globally since 1990 (WHO, 2017). Importantly, the burden remains higher in Africa compared to the overall global burden. This implies that more interventions are required to further take the diarrhoeal trend down. Among others, food hygiene interventions could be required considering that they have not been given a priority in the prevention of childhood diarrhoea (WHO, 2015b); and there has been gaps on the role of food hygiene in the prevention of diarrhoea at national and international levels (Kaferstein, 2002).

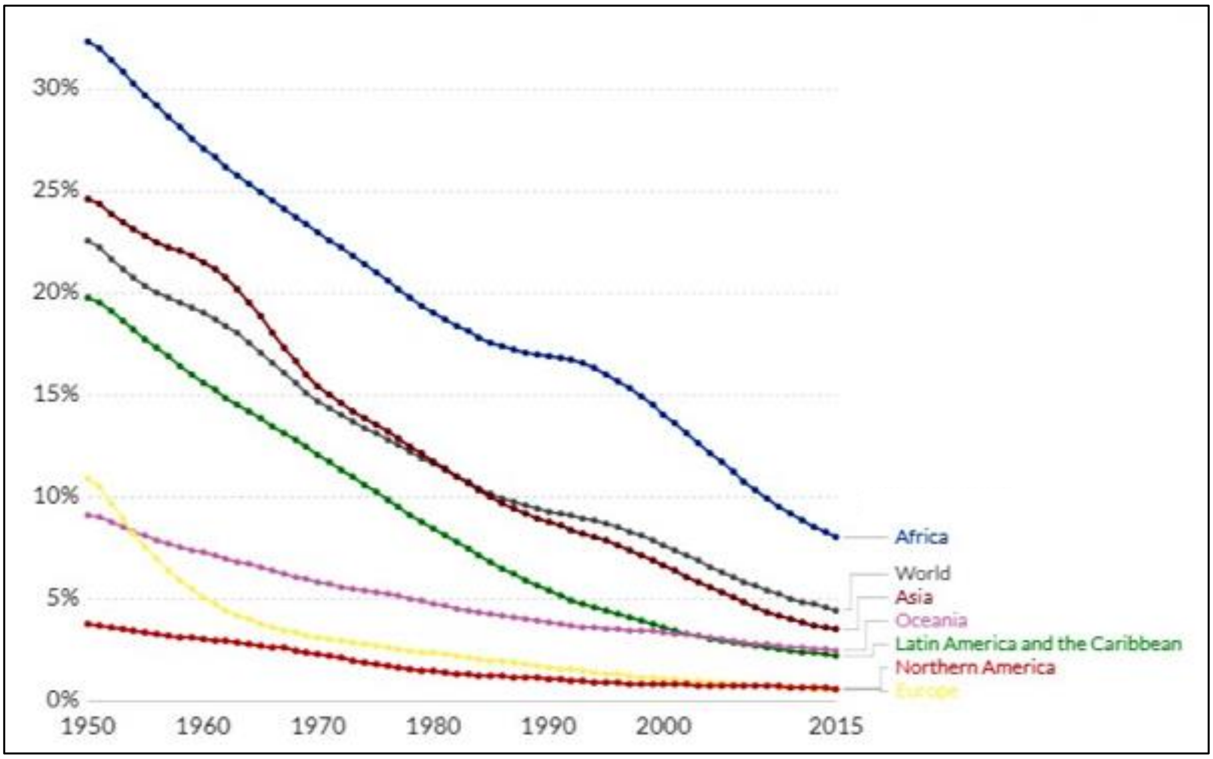

Figure 8: Global trend of child mortality between 1950 – 2015 (Roser et al., 2015)

Experts have proven that incidence of diarrhoea among children aged 5 years and below is high after 6 months of age (Ehiri et al., 2001b; Oni, 1996; Walker et al., 2013). Previous review has shown that up to 70% of all cases of diarrhoea were due to contaminated food where *E.coli* alone contributed 25% mainly among children (Motarjemi et al., 1994b).

In conclusion, this section highlights that the burden of foodborne diseases remains high worldwide, with increased morbidity and mortality in low and middle income regions of the world (i.e. Africa and south East Asia regions) where children aged five years and below are mostly affected. As such tailor made, context appropriate interventions are required to address the current burden of foodborne disease with a primary focus on resource poor settings.

2.5 Microbial growth and transmission of pathogens in food

Food, principally when stored or prepared under ambient temperature, provides a favourable environment for the survival and growth of microorganisms. It has been highlighted that favourable temperature for bacterial growth in food ranges from 20 – 40^{o}C; with below 6^{o}C and above 60^{o}C as low risk zones (Lanata, 2003). Food exposed to favourable temperatures is very common in resource challenged settings. For instance, in Liberia, it was noted that infant cooked food stored for a long time in a bowl wrapped in a piece of cloth under ambient temperature was highly contaminated compared to food that was kept for a shorter period (Mìlbak et al., 1989). Similarly, other studies in west Africa (Gambia and Nigeria) noted high microbial growth in freshly prepared and stored food (gruel and *Ogi* respectively) due to poor hygiene during preparation, while less microbes were recorded in fresh milk. However, multiplication of microbes (i.e. *coliforms*, *Escherichia coli* and *Staphylococcus aureus*) to dangerous levels was noted after prolonged storage periods both in gruel and milk (Barrell & Rowland, 1980; Omemu & Omeike, 2010). It has been shown that microbes increase significantly in wet food stored for over 4 hours under ambient temperature in East Asia and sub – Saharan Africa (Henry et al., 1990; lack et al., 1989). Furthermore, it has been established that bacteria (e.g. *E.coli, S. aureus* and *Shigella flexneri*) can multiply from 10^{3} to 10^{8} Colony Forming Unit (FCU) per gram in cooked food within 3 hours when stored under ambient temperature (Black et al., 1989; Islam et al., 1993; Lanata, 2003; Molbak et al., 1989).

Generally, microbial pathogens in food originate when the food has been in contact with human or animal faecal matter either directly or indirectly. Food provides a critical and direct pathway for the introduction of microbial pathogens into the gastrointestinal tract (GIT) of humans. The transmission of pathogens mainly occurs in the household environment due to poor food preparation, feeding and storage practices (i.e. in relation to temperature, place and time), which result in food highly contaminated with microbes by the time of consumption (Ehiri et al., 2001a; Gautam & Curtis, 2013; Motarjemi et al., 1994a; Omemu & Omeike, 2010). Within the domestic environment, food stored at ambient temperature can be conducive for the survival and growth of bacteria such as *E.coli*, *Shigella spp*., and species of *Salmonella*; the fingertips can be reservoirs of such bacteria (Curtis et al., 2011). Studies in rural northern Thailand showed that the type of food, method of food preparation, season of the year, mother's age, education (Imong et al., 1995b) and mode of cleaning utensils (Imong et al., 1989) greatly contributed to complementary food contamination levels. Bacterial contamination of feeding utensils, food storage and reheating temperatures were also noted as important factors in food contamination (Lanata, 2003). Post-cooking activities that include unhygienic handling of kitchen utensils, and poor handwashing practices are risk factors that have been associated with diarrhoea-causing pathogens in food in Malawi (Taulo et al., 2008, 2009).

2.6 Hazard analysis and critical control points (HACCP)

The HACCP approach has been used to ensure food safety mostly for international trade worldwide. The basics of HACCP were developed in 1960s by the Pillsbury Company in collaboration with the National Aeronautics and Space Agency (NASA) in the USA, Natick Laboratories and the US Army to check the quality of food supplied to NASA astronauts (Pierson & Corlett, 1992). It was later adopted in the guidelines of the Codex Alimentarius Commission (CAC) in 1969 as the main principle of their International Code of Practice in relation to food hygiene (CAC, 1969).

The HACCP approach operates on 7 steps which identifies potential hazards associated with food production (i.e. from farm to folk), assesses the level of risk, and suggests relevant recommendations to mitigate the risk (Mortimore & Wallace, 2013). The core principles of HACCP from hazard identification through to documenting all procedures are presented in Figure 9.

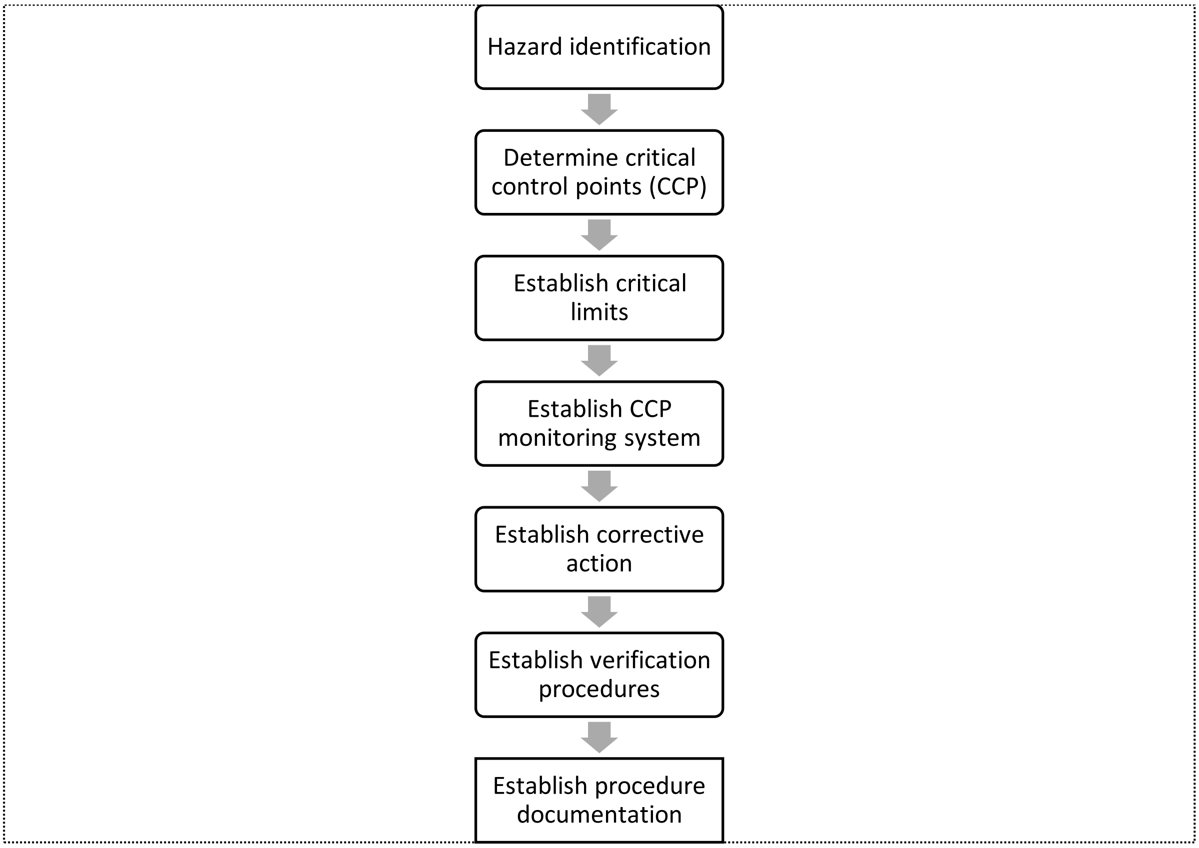

Figure 9: Process flow of Hazard Analysis Critical Control Point (Bryan & Organization, 1992)

Although HACCP has been applied extensively in the food industry in High Income Countries (HIC), few experimental studies have assessed its effectiveness in domestic settings in low income countries. As such, there was a directive by FAO/WHO that the use of the HACCP approach should be explored in low income countries to address the increase in foodborne disease burden (FAO/WHO, 1984). Of those studies that were carried out, the HACCP approach was found to be significant in reducing the bacterial load of complementary food in

Mali where cooking, cooling that comes after cooking, reheating after storage, and cooling that follows after reheating complementary food were identified as the CCPs (Touré et al., 2011a). Similarly, other early studies on HACCP found the approach to be useful when applied to domestic food preparation in LMIC (Michanie et al., 1987, 1988). Ehiri et al (2001) conducted a HACCP study in Nigeria which identified cooking, storage and reheating of complementary food as CCPs in the prevention of microbial contamination in food. Similarly, a study in India used the HACCP approach and identified cooking and storage of *chapati* as critical in controlling microbial contamination (Sheth et al., 2000). While Griffith (1994) concluded that application of the HACCP approach in the preparation of food in homes could be beneficial if applied in domestic kitchens globally.

2.7 Foodborne diseases in High Income Countries (HIC)

Communicable foodborne diseases continue to be a major cause of illness in HIC. In 2005, the WHO reported that every year one third of the population in developed countries has an infection whose pathogens are acquired through contaminated food (WHO, 2005). In the USA alone; in 2011, it was reported that 1,000 disease outbreaks and an estimated 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths occurred due to contaminated food (Scallan, Griffin, et al., 2011; Scallan, Hoekstra, et al., 2011). While in the UK in 2005, 2,366,000 cases, 21,138 hospitalizations, 718 deaths were reported (Adak et al., 2005). While in Australia contaminated food causes 4.1 million foodborne cases costing 1.2 million Australian dollars annually (OzFoodNet, 2015). This indicates that foodborne diseases remains a public health challenge in developed countries (Khabbaz et al., 2014). This has resulted in many studies conducted in developed countries to fully understand the root causes of foodborne diseases and possible interventions have been suggested. Some of the interventions include provision of training to both food handlers and consumers (Majowicz et al., 2017; Soon et al., 2012). However, it has been proven that such trainings focuses on the provision of information, and does not necessarily deal with the behaviours that cause foodborne illnesses (Mathias et al., 1994; Wright & Feun, 1986). Furthermore, it has been reported that knowledge alone is insufficient to trigger preventive practices and that some mechanisms are needed to motivate action and generate positive attitudes (Egan et al., 2007; Pilling et al., 2008). Egan et al (2007) concluded that there is a need to come up with food hygiene intervention methods that have been demonstrated to not only impart knowledge, but also bring about behaviour change.

In a study in Europe, it was noted that lack of adherence to "use by" dates and ineffective refrigerated storage of foods, especially among adults was amongst the contributors to foodborne diseases (Evans & Redmond, 2014). The study suggested targeting food safety education to reduce risks mostly associated with listeriosis in the home. In another study conducted in the Netherlands (Fischer et al., 2007), it was observed that consumers had adequate knowledge about cross contamination and heating in the prevention of foodborne illness, however, this knowledge was not translated into practice. The study noted actual behaviour to prepare safe food was as a result of addition of behavioural cues to an information intervention and not knowledge about food safety.

In order for a food hygiene intervention to be successful, it is necessary to understand different behaviours performed by different consumers. It has been reported that it is important to identify how likely it is that the general public conduct specific self-protective behaviours, as there is evidence that people exhibit profound individual differences in the extent to which they adopt such behaviours (Fischer et al., 2007).

Earlier studies have assessed factors that lead to contamination of food in developed countries which include unhygienic storage conditions, contaminated utensils, poor personal hygiene, inadequate cooking and demand for cheap food (Lynch et al., 2006; Medeiros et al., 2004; sanlier, 2009). Contamination of food at different points during storage, preparation and eating has been associated with age and gender, as well as exposure to the media. It has been highlighted that men, the youth and the very old are prone to prepare unhygienic food (Fein et al., 2011). The same author suggested that high level of exposure to the media is important in raising awareness of consumers about food safety hazards.

2.8 Foodborne diseases and food hygiene studies in Low and Middle Income Countries

2.8.1 Foodborne diseases in low and middle income countries

While in developed countries information regarding food poisoning and foodborne diseases is available, there is limited data about the cause and extent of such diseases in LMICs. The WHO reported that epidemiological data about foodborne diseases in LMICs remains very limited (WHO, 2015b). This is not to suggest that contaminated food is absent, but rather foodborne outbreaks are often not reported, unrecognized, or may only be reported when there is a major public health or economic crisis (WHO, 2015b). Detailed systematic foodborne investigation initiatives which include epidemiological studies are not frequently undertaken, while public health authorities and the general public learn about foodborne disease outbreaks from the news media (Käferstein, 2003). It has been observed that in some instances foodborne diseases are just reported as diarrhoeal diseases because the specific disease-causing agent is not identified. Hence the specific proportion of foodborne diseases in LMICs is not clear (Woldt & Moy, 2015). Käferstein (2003) noted that in the pre-2000 period, food safety was not considered a priority, but rather a privilege for developed countries, hence governments in low income countries did not invest much in food safety issues, hence little is known about foodborne diseases in this part of the world.

Despite the limited work on foodborne disease in LMICs, some research has been undertaken. Section 2.8.2 below presents a review of seven food hygiene studies (Table 2) that were conducted in seven LMICs to identify key priority areas that could be targeted to improve food hygiene practices at household level. While Sections 2.8.3 to 2.8.5 present another set of seven food hygiene studies (Table 3) that were conducted to test food hygiene interventions that were designed to improve food hygiene behaviours in household setting in LMICs. The author of this Thesis conducted a narrative review of journal articles published in peer reviewed journals. Criteria for the selection of the 14 studies included:

1. Journal articles that were published in peer reviewed journals
2. Journal articles that included the following as key words: complementary food hygiene, household food hygiene, food hygiene behaviours, microbial contamination of food and household food hygiene interventions
3. Methods appropriate to research questions about household food hygiene, with emphasis on randomized controlled trials, controlled before and after studies, uncontrolled studies, interrupted time series, and surveys
4. Studies linked to theory of behaviour change
5. Clearly stated aims and objectives
6. A clear description of context with priority on LMICs

7. A clear description of the study population, with priority on children under 5 years of age
8. A clear description of fieldwork methods, including use of accepted HACCP strategy methods to determine key problems and critical control points, and use of accepted univariate and multivariate analyses to determine statistically significant associations and risk factors

2.8.2 Studies on the identification of key priority areas for action to improve food hygiene practices at household level in low and middle income countries

Researchers have reported on several exploratory studies that have been conducted to identify key critical control points that may need to be considered for food hygiene interventions (Table 2). This section reviewed seven studies that were conducted to identify key priority areas for action to improve food hygiene practices at household level in LMICs. The HACCP approach was used to explore food preparation and storage procedures that contribute to food contamination, and microbial growth and survival in Nigeria (Ehiri et al., 2001a). In this study where food samples were collected for microbiological analysis, three critical control points were identified: purchase of uncontaminated food; thorough cooking and reheating of food; and decreasing storage time of left-over food at ambient temperature. Similarly, a study in Bangladesh that used the HACCP approach identified thorough cooking and reheating of food as critical to the prevention of diarrhoea. In addition, the study reported other critical control points: adequate handwashing with soap; adequate washing of utensils with soap; adequate treatment of water; and covering of food with a lid (Islam et al., 2013). While a HACCP approach study in the Dominican Republic identified a number of critical control points for children's milk that included heating, holding after heating, cleaning and disinfecting bottles, nipples and pans used to store milk, and utensils used to dispense the milk (Michanie et al., 1987). In India, collection of samples with subsequent microbiological analysis revealed four critical points: thorough cooking and reheating of food; adequate handwashing with soap; adequate washing of utensils with soap; and decreasing storage time at ambient temperature of ready to eat food (Sheth et al., 2000). A study in Brazil found that thorough cooking and reheating of food, adequate handwashing with soap and decreasing storage time of food at ambient temperature were important factors for consideration to improve quality of household foods (Sobel et al., 2004). Similarly, thorough cooking and reheating of food and decreasing storage time of food at ambient temperature were identified as critical points for interventions in Zambia (Schmitt et al., 1997). While in Mali, thorough cooking, reheating, washing utensils with soap before use and covering of left-over food with a tight fitting cover were identified as critical to prevent transmission of diarrhoeal pathogens through food (Touré et al., 2011a). Table 2 summarizes the findings from these seven studies which identified various practices that predisposed children and other household members to diarrhoeal pathogen exposure. Such practices included use of contaminated raw food items, contaminated hands while preparing food or eating, contaminated utensils, long storage of cooked food (i.e. storage over six hours), inadequate time and temperature to reheat stored left-over food, use of contaminated water during food preparation and cooked food left uncovered.

Table 2: Critical control points to promote food hygiene practices at household level

Critical control point	**Nigeria** (Ehiri et al., 2001a)	**Bangladesh** (Islam et al., 2013)	**Dominican Republican** (Michanie et al., 1987)	**India** (Sheth et al., 2000)	**Brazil** (Sobel et al., 2004)	**Zambia** (Schmitt et al., 1997)	**Mali** (Touré et al., 2011b)
Thorough cooking and reheating	√	√		√	√	√	√
Purchase uncontaminated food	√						
Decrease food storage time	√			√	√	√	
Handwashing with soap		√		√	√		√
Washing utensils with soap		√	√	√			√
Treatment of water		√					
Covering of food with a lid		√					√
Heating of milk			√				
Cooling of milk after heating			√				

As shown in Table 2, thorough cooking and reheating of food were identified by six out of the seven studies as critical control points for improving food hygiene practices (Ehiri et al., 2001a; Islam et al., 2013; Schmitt et al., 1997; Sheth et al., 2000; Sobel et al., 2004; Touré et al., 2011b). While handwashing was identified by four studies (Islam et al., 2013; Sheth et al., 2000; Sobel et al., 2004; Touré et al., 2011b). In four studies, reduced storage time of left-over food was also identified as a critical point in the promotion of hygiene at household level (Ehiri et al., 2001a; Schmitt et al., 1997; Sheth et al., 2000; Sobel et al., 2004).

Previous studies have also identified various contextual factors influencing performance of recommended WASH and food hygiene behaviours. For instance, increased handwashing behaviour has been associated with presence of a fixed handwashing facility, soap, water and wealth of the household (Bowen et al., 2013; Gilman et al., 1993; Scott et al., 2007; Seimetz et al., 2016a).

2.8.3 Intervention studies to improve food hygiene practices in low and middle income countries

Previous research studies have designed and delivered interventions aimed at improving food hygiene practices in urban and rural household settings in low income countries. In this thesis, seven food hygiene intervention studies conducted in Nepal (Gautam et al., 2017a), Gambia (Manjang et al., 2018), Brazil (Monte et al., 1997), Vietnam (Takanashi et al., 2013), Mali (Touré et al., 2013), Bangladesh (Islam et al., 2013) and India (Sheth et al., 2000) have been reviewed. The seven food hygiene intervention studies used different methods to identify the critical practices for intervention. For instance, formative research that involved structured observation of behaviours, household surveys and Focus Group Discussions (FGDs) were used to inform designing of behaviour change interventions to improve food hygiene practices in Nepal (Gautam et al., 2017a), Gambia (Manjang et al., 2018), Brazil (Monte et al., 1997) and Vietnam (Takanashi et al., 2013). For these studies, selection of behaviours was based on various factors which included the extent of undesired behaviours in the communities, the likelihood of reducing diarrhoeal pathogens if practicing of the behaviours is to change, and the feasibility of changing the behaviours with reference to the context where they occur. The remaining studies, conducted in Mali (Touré et al., 2013) and Bangladesh (Islam et al., 2013), used the HACCP approach to identify the critical control points to be targeted with the interventions. In the study in Bangladesh, four critical control points were identified: handwashing with soap at selected times (before food preparation, before child feeding, after cleaning child's bottom and after using a latrine); use of safe water and soap to wash utensils; thorough cooking of food; thorough reheating of stored cooked food; and covering of cooked food with a tight fitting cover (Islam et al., 2013). The targeted mothers were split into an intervention group and a control group, and those in the intervention group were trained for four weeks on how they could prevent bacterial pathogens contaminating the food for their child. The study confirmed that the HACCP approach substantially reduced the weaning food contamination among the intervention group. Similarly in Mali, an intervention was implemented following an earlier experimental study which identified four corrective actions to improve the quality of complementary food: handwashing with soap at critical times (i.e. before food preparation, before child feeding/eating, after cleaning child's bottom and after using the latrine); washing utensils with safe running water and soap; use of safe water for preparing food; thorough cooking of food; thorough reheating of stored cooked food; and covering of cooked food with a tight fitting cover (Touré et al., 2011b). The study participants were also grouped into an intervention group and a control group. After nine months of implementing food hygiene promotion activities in the intervention area, a significant reduction in pathogenic microorganisms was observed in food for the child of the intervention households. Three months after implementation of the intervention, only 3% (a reduction from 47% noticed at baseline survey) of fish soup samples were contaminated when freshly cooked, while none of the samples were contaminated after reheating amongst the intervention households (Touré et al., 2013).

As indicated in Table 3, all seven intervention studies reviewed targeted mothers or child caregivers who had children aged between 6 – 59 months (Gautam et al., 2017a; Islam et al., 2013; Manjang, 2016; Monte et al., 1997; Sheth, 2006; Takanashi et al., 2013; Touré et al., 2013). A range of behaviours were targeted by these studies where handwashing with soap (with variation on the selected critical times) was included in all the seven studies. Repeated group meetings and household visits were the communication methods used to deliver the interventions in all the seven studies. For instance, in Nepal, six intensive household visits and three group meetings were conducted within a space of three months. In Mali, follow up of mothers through household visits were conducted every two weeks for 9 months. Similarly, intensive household visits in Bangladesh were conducted for a period of 4 weeks. The authors reported that use of community group meetings and households visits strengthened adoption of the new behaviours by the mothers/child caregivers. Considering that most food hygiene intervention studies were too intensive to realistically be scaled up, it has been suggested that more studies are required to assess the frequency and intensity of exposure to messages and key practices needed for adoption of targeted behaviours (i.e. how to be most effective with fewer resources) (Woldt & Moy, 2015).

Five of the seven studies (in India, Brazil, Vietnam, Nepal and Gambia) incorporated Social Behaviour Change and Communication (SBC) strategies in their interventions to support bringing change in the targeted behaviours (Gautam et al., 2017a; Manjang et al., 2018; Monte et al., 1997; Sheth, 2006; Takanashi et al., 2013). In Brazil, although the SBC strategy helped to bring the desired change, the authors recommended the need to come up with a communication strategy for the sustainability and scalability of such interventions (Monte et al., 1997). In India, the promotion messages were disseminated through calendars, pamphlets, posters, flash cards, role play, storytelling, and puppets (Sheth, 2006). While in Vietnam, workshops, newsletters, loudspeaker announcements, bulletin board announcements, and flip charts were used as channels of communicating food hygiene messages to the study participants (Takanashi et al., 2013). In Nepal, public community events, mother/child caregiver group events, household visits, rewards, games and kitchen makeover were used to facilitate behaviour change (Gautam et al., 2017a). The authors reported that the messages were tailor made to the local context. Thus, the messages were clear, and materials were simple to use and attractive to generate interest among the study participants.

A number of the studies used influential leaders and change agents during delivery of the interventions, and this was reported to have a positive influence on the adoption of the targeted behaviours by the mothers/child caregivers (Monte et al., 1997; Takanashi et al., 2013). The success of an intervention trial in Brazil was attributed to the field workers who were recruited from the study communities and had a good relationship with the study participants (Gautam et al., 2017a). Similarly, recruitment of local female food hygiene motivators who were already community health volunteers in the study area in Nepal simplified delivery of the intervention since they already had good rapport with the study participants. Takanashi et al (2013) in Vietnam also attributed the success of the food hygiene intervention study to the good interpersonal relationship between the research team and the study participants during household visits.

As shown on Table 3, implementation period of the interventions for the seven reviewed studies varied greatly, with the longest interventions conducted in Vietnam (Takanashi et al., 2013) for 2 years, while the shortest interventions were those implemented for 1 month in Bangladesh, India and Brazil (Islam et al., 2013; Monte et al., 1997; Sheth, 2006). All the studies were randomized controlled trials that had an intervention and control group except for the Vietnam and Brazil studies (Monte et al., 1997; Takanashi et al., 2013).

Improvement in behavioural practices was used to measure the outcome of most of the intervention studies (6 out of 7) except for the study conducted in Bangladesh which measured the temperature and bacteriological quality of the food (Islam et al., 2013). Adoption of behaviours was noted in all the six studies that aimed to assess changes in food hygiene practices. The mothers/child caregivers showed behavioural improvement in washing of utensils with soap, handwashing with soap, thorough cooking of food, thorough reheating of stored cooked food, covering of stored cooked food with a tight fitting cover and use of safe water for preparing food and washing utensils. Five out of the seven studies measured childhood diarrhoea prevalence as the outcome where significant reduction in diarrhoea was noted at the end of the intervention (Gautam et al., 2017a; Islam et al., 2013; Sheth, 2006; Takanashi et al., 2013; Touré et al., 2013). The studies in Mali and India further showed improvement in the level of knowledge among mothers/child caregivers (Sheth, 2006; Touré et al., 2013). However, sustainability of the outcome was not reviewed after completion of the intervention.

Table 3: Selected food hygiene intervention studies at household level implemented in low and middle income countries (Woldt & Moy, 2015)

Title and author, year	Study area and design	Target population	Targeted behaviours	Intervention activities	Communication channel	Number of study participants	Duration of the intervention	Outcome	Results
Trial of a Novel Intervention to Improve Multiple Food Hygiene Behaviours in Nepal, Gautam et al (2017)	Nepal (Rural), Randomized control trial	Mothers of children 6 – 59 months	Thorough cooking, Washing utensils with soap/ash, handwashing with soap, proper storage of cooked food, reheating of cooked food, boiling of water/milk	Games, rewards, storytelling, drama, competitions and kitchen makeovers	Local rallies, Group meeting with mothers and household visits	219	3 months	Adoption of improved behaviours, diarrhoea prevalence.	The target behaviours were more common in the intervention than in the control group (43% versus 2% during follow-up
Cluster Randomized Controlled Trial to Investigate the Effectiveness of Weaning Food Hygiene Intervention for Mothers in Rural Gambia, Manjang, B (2016)	Gambia (Rural). Randomized control trial	Mothers of children 6 – 24 months	Washing of pots and utensils before serving food, handwashing with soap	Games, rewards, drama, Songs, competitions, video show	Local rallies, Group meeting with mothers and fathers (separately), and household visits	615	3 months	Adoption of improved behaviours	Adoption of improved practices higher among intervention (72%) compared to control (19%) group after intervention
Designing educational messages to improve weaning food hygiene practices of families living in poverty, Monte et al (1997)	Brazil (Urban), Trial of improved practice	Mothers of children 0–11 months	Handwashing with soap, boiling water for reconstituting powdered milk, feeding gruel with cup and spoon rather than using bottle, not	Training of mothers about the targeted behaviours	Training of mothers, household visits	75	1 month	Adoption of improved behaviours	53–80% of mothers adopted at least 1 Practice. 60% of mothers who tried to adopt 4 practices were able to do so for 4 weeks

			storing gruels and milk.						
Long term impact of community based information, education and communication activities on food hygiene and food safety behaviours in Vietnam: A longitudinal study, Tanakashi et al (2013).	Vietnam (Urban), Longitudinal study	Mothers/care givers of children aged 6 – 48 months	Handwashing with soap, use of separate utensils between raw and cooked food, washing child's utensils with soap, preparing food on a table	Village loudspeaker announcements, placing of posters in strategic places, meeting with mothers/child caregivers,	workshops, newsletters, loudspeaker announcements, bulletin boards, and flip chart, household visits	185	2 years	Diarrhoea prevalence, Adoption of improved behaviours	Significant reduction in diarrhoea.. Adoption of the 11 out of 17 food hygiene behaviours
Piloting an intervention to improve microbiological food safety in peri urban Mali, Toure et al (2013).	Mali (Urban), Randomized control trial	Mothers/care givers of children aged 6 – 18 months	Handwashing with soap, washing utensils with soap, use of safe water for preparing food, thorough cooking of food, thorough reheating of food, cover cooked food with tight fitting lid during storage.	Training of mothers/child caregivers, follow up of mothers/child caregivers in households	Group meetings, household visits.	60	9 months	Presence/absence of pathogens in food, Adoption of improved behaviours, increase in knowledge	Significant reduction of pathogens in complementary food among the intervention group. improved knowledge and performance of the targeted behaviours among participants in the intervention group.
Hygiene intervention reduces contamination of weaning food	Bangladesh (Rural), Randomized control trial	Mothers/ caregivers of children 6–18 months of age	Handwashing with soap, use of safe water for preparing food and washing utensils, thorough	Training of mothers/child caregivers	Group meetings	60	1 month	Presence/absence of pathogens in food and water, temperature	Significant reduction of the pathogens in food and water among the intervention group.

in Bangladesh, Islam et al (2013)			cooking of food, thorough reheating of cooked stored food, covering the food with a lid during storage.					of food before eating.	Temperature of food during serving was high among the intervention group.
Food safety education as an effective strategy to reduce diarrhoeal morbidities in children less than two years of age, Sheth et a l (2006).	India (Urban), (study type not known).	Mothers of children aged 6 – 24 months	-	Training of mothers/child caregivers	Group meetings	-	1 month	Diarrhoea prevalence, Adoption of improved behaviours, improved knowledge.	Reduction in diarrhoea prevalence. Improvement in the adoption of targeted behaviours by the intervention group. Improvement in knowledge on the causes of diarrhoea among the intervention group.

2.8.4 Implications of food hygiene studies in low and middle income countries

Literature has shown that critical control points identified as crucial in interrupting the transmission cycle of diarrhoeal diseases include: thorough cooking and reheating of food; washing utensils with soap; handwashing with soap (before food preparation, before child feeding/eating, after cleaning child's bottom and after using a latrine); and covering of food with tight fitting cover (Gautam et al., 2017a; Islam et al., 2013; Touré et al., 2013). These key critical points to keep food safe relate well with those identified by the WHO as five keys to safer food, that include keeping clean (e.g. hands and utensils), separating raw and cooked food, cooking thoroughly, keeping food at safer temperatures, and using safe water and raw materials (WHO, 2014). Amongst the key points, thorough cooking and reheating have been strongly emphasized by previous research studies (Gautam et al., 2017a; Islam et al., 2013, 2013; Monte et al., 1997). However, these studies did not provide details of the perceptions (which include motivators and barriers) of the community members about their ability to perform these behaviours. Similarly, handwashing with soap at the four critical times (before food preparation, before child feeding/eating, after cleaning child's bottom and after using a latrine) has been highly recommended (Curtis & Cairncross, 2003a). However, the handwashing with soap practice at household level is affected by an array of factors including availability of the handwashing facility, soap and water (Biran et al., 2005; Scott et al., 2007; Seimetz et al., 2016b). Interventions to improve and sustain handwashing with soap may need to focus on all the critical factors in addition to ensuring that key stakeholders and communities select options that are applicable to their context.

Despite the availability of these food hygiene critical control points, it is necessary that researchers should always assess which gaps (critical control points) are specifically related to their study areas. This will subsequently lead to the design of an effective, tailor-made food hygiene intervention package. As suggested earlier, it is important that food hygiene interventions should not be designed to address numerous behaviours at once, but rather a few, whose implementation will drastically contribute to the reduction of diarrhoeal pathogens in food (USAID, 2011).

The use of the HACCP approach has been found to be very effective in the identification of critical control points at household level (Ehiri & Prowse, 1999). Such that it may be necessary to include this approach during the initial assessment to understand the causes and factors responsible for diarrhoeal diseases among children at household level. It has been argued that adequate bacteriological evidence exists that may inform the design of a food hygiene intervention without carrying out additional microbial analysis studies; though context specific studies may be required to validate the available evidence (Woldt & Moy, 2015). The HACCP process can be expensive and time consuming if microbiological assessment is applied (Monte et al., 1997). In addition, the HACCP approach does not take into account or establish potential effective Behaviour Change Techniques (BCTs). Further, despite its benefits, it has been argued that it is not a requirement to conduct such HACCP analysis in each and every food hygiene study (Woldt & Moy, 2015). Considering that HACCP has been effectively used, there is information already available from previous HACCP studies which may be used to provide direction on the specific behaviours to be targeted with a food hygiene intervention. Woldt and Moy (2015) further suggested that observational studies could be used to identify the critical behaviours based on existing bacteriological evidence which could later be used to develop tools for the quantification of the risky behaviours. However, this should be carefully considered to ensure that any suggested behaviours targeted within an intervention should significantly reduce diarrhoeal pathogen exposure. Nevertheless, HACCP studies still remain an important tool in the identification of critical control points and should not be ruled out if context specific interventions are to be designed for a particular area.

In addition to the HACCP approach, it is important that researchers should incorporate additional formative research methods to advise on how food hygiene interventions should be designed. Formative research provides useful information about food hygiene perceptions and practices that reveal motivators and barriers (e.g. culture, norms and beliefs) that may need to be considered during the design of an intervention (Woldt & Moy, 2015). Personal status and nurture/desire to care for the child were identified as some of the motivators to the performance of food hygiene behaviours in rural Nepal (Gautam et al., 2017a; Gautam & Curtis, 2013). While a systematic review in selected LMICs showed that social norms (doing what is perceived as being performed by others) were strongly associated with washing hands using soap (Curtis et al., 2009); it is important to note that Curtis et al, (2009) did not find fear of illness or disease as a strong motivator to the performance of handwashing with soap. In a formative study in Indonesia, mothers were found to associate childhood diarrhoea with children's developmental milestones (e.g. crawling and teething) (Usfar et al., 2010). Moldt and Moy (2015) argued that in circumstances like these, it would be difficult to convince the mothers to follow recommended food hygiene behaviours to prevent diarrhoea in children. Thus, the author concluded that other motivational messages such as “nurturing” may be more important than threatening them with fear messages. Use of cues for action in food hygiene interventions has been found to be very helpful in bringing change worldwide. For instance, use of behavioural cues (such as placing of food hygiene posters in strategic places) were found to be significant in reducing cross contamination rather than depending on food hygiene information alone in Vietnam (Takanashi et al., 2013). Similarly, disruption of environmental setting (i.e. change in kitchen set up) which in some way acted as a cue to the mothers of young children was useful in bringing the desired behaviour change (Gautam et al., 2017a).

In the seven food hygiene intervention studies assessed, different channels of communication such as household visits, group meetings with mothers/child caregivers and provision of SBC materials (e.g. posters) were used to disseminate the intervention messages. Much as each channel of communication is essential, previous research has shown that combining the channels of communications in a WASH behaviour change intervention study is more beneficial since it reaches the wide community (Scott et al., 2008). However, as earlier suggested, it is important to assess the most effective combination channels of communication applicable to a specific area (Curtis et al., 2011).

The intervention studies reviewed in this chapter were mostly intensive and the activities such as household visits and group meetings were repeatedly conducted to strength the interaction between the research team and study participants. In addition, various change agents were used to deliver the intervention activities. The success of the intervention studies was in part attributable to the intensive/repeated approach together with the use of the change agents. However, it has been reported that previous food hygiene intervention studies did not measure the intensity of the interventions, how much intervention produces how much behaviour change and at what cost (Woldt & Moy, 2015). Furthermore, it has been questioned as to what type of change agents are most influential in bringing the recommended changes in behaviour (Curtis et al., 2001).

Importantly, most previous research interventions on food hygiene did not include social and behaviour change theories (Woldt & Moy, 2015). For instance, only two (Gautam et al., 2017a; Manjang et al., 2018) out of the seven intervention studies reviewed in this chapter applied the behaviour change model (i.e. the Behaviour Centred Design (Aunger & Curtis, 2016) in the design, implementation and evaluation of the interventions. It is important that future intervention studies should incorporate behaviour change theories in order to clearly assess the behavioural factors such as knowledge, attitude, beliefs, social norms, availability and access to resources that affect the sustained performance of the desired behaviours at individual, household/family and community level (Woldt & Moy, 2015).

2.8.5 Limitations of the food hygiene intervention studies

Despite reported success on previous food hygiene intervention studies, limitations have also been highlighted. The short duration of the studies has been identified as one of the major limitations. For instance, the duration of five out of the seven studies highlighted in Table 3, ranged from 1- 3 months. Only two studies, in Mali and Vietnam, were implemented for 9 months and 2 years respectively. Studies of longer duration are necessary to determine if the results are reproducible over a large scale (Woldt & Moy, 2015). In addition, Woldt and Moy (2015) recommended that future studies should assess factors that contribute to long term adoption or non-adoption of desired food hygiene behaviours.

Two of the seven studies, in Brazil and Vietnam, did not include control groups (Monte et al., 1997; Takanashi et al., 2013). It is important that intervention studies include control groups to allow comparison of the key outcomes with the intervention group when measuring effectiveness of the trial. Effectiveness of some of the intervention studies (e.g. study in Vietnam) depended on self-reported data. However, it has been argued that use of observations has been helpful in assessing changes in targeted behaviours among study participants (Curtis et al., 1993). In a systematic review by Woldt and Moy (20015), the authors reported that some intervention studies provided incentives that had the possibility of affecting the results (i.e. through bias). For example, the study in Mali provided handwashing kits to both the intervention and control groups (Touré et al., 2013).

Importantly, use of behaviour change theories was very uncommon in the previous research related to food hygiene interventions. Use of behaviour change models provide a clear guidance on how interventions should be designed, implemented and evaluated (Woldt & Moy, 2015).

2.9 Water, Sanitation and Hygiene Behaviour Change Theories

It has been reported that safe water supply, sanitation and hygiene initiatives could reduce diarrhoeal related deaths by 65% (WaterAid, 2009). Governments and donor partners have invested a lot of resources towards provision of WASH infrastructure such as drilling of boreholes, innovation of water treatment technologies, construction of pit latrines and installation of handwashing facilities (Peal et al., 2010). Use of low cost WASH technologies that are context specific can considerably contribute to public health improvements (Howitt et al., 2012). However, it has been reported that provision of WASH infrastructure alone may not facilitate its intended use (Cairncross & Shordt, 2004). Stanton et al (1992) and Pearl et al (2010) recommended that in order to achieve maximum utilization of WASH infrastructure and a high degree of hygiene behaviours, behaviour change strategies should be integrated in WASH programming.

Performance of a behaviour results from the processes that happen in the brain which depends on multiple factors such as individual’s knowledge on a particular behaviour, beliefs and emotions (Contzen & Mosler, 2015b). As such, these factors also known as ‘behavioural determinants’ that determine performance of undesirable behaviours must be well understood and targeted with behaviour change interventions. It is important that programme implementers know which behavioural factors contribute to the performance of unhealthy behaviours among specific community members. Such information is necessary for the practitioners to know which interventions change psychosocial factors for conducting successful behaviour change campaigns (Mosler, 2012).

Previous research has explored the behavioural factors that determine specific WASH behaviours. This has led to social scientists developing theoretical models, explanatory frameworks, and decision making models to provide guidance on how behaviour change interventions should be developed to promote low cost technologies that enable improved water, sanitation and hygiene (WASH) practices in LMICs (Dreibelbis et al., 2013a). Application of such behaviour change theories in the design and implementation of social behaviour change programmes have the potential to facilitate improved WASH behaviours (Baker et al., 2010; Glanz & Bishop, 2010). So far, researchers have developed different WASH behaviour change theories that are designed to improve WASH behaviours in various contextual and environmental conditions, targeting single or multiple behaviours. Such models are based on historical theories that were founded on the principles of cognitive and social psychology, such as the Health Belief Model (Rosenstock, 1974), the Protection Motivation Theory (Floyd et al., 2000), the Health Action Process Approach (Schwarzer, 2008) and the Theory of Planned Behaviour (Ajzen, 1991). However, the historical theories could not cover all the possible behavioural factors. For instance, the Theory of Planned Behaviour and Health Belief Model were found not to address the issues of impulsivity, habit, self-regulation, associative learning and emotional processing (West & Brown, 2013). Hence, recent theories have been developed to address some of these gaps. The sections below highlight some of the recent studies that developed/reviewed behaviour change theories that can be applicable to food hygiene behaviours.

2.9.1 COM–B Framework

This model focuses on three pre-requisites for behaviour change (Michie et al., 2011):

1) **Capability**: the person has the psychological and physical capacity to perform a particular behaviour. It includes having the knowledge and skills for the performance of the behaviour.

2) **Opportunity**: the person has all the external factors, which include social and environmental factors, that enables the execution of a behaviour.

3) **Motivation**: the person has all psychological processes in the brain that stimulates performance of a behaviour. This includes an individual's external strong conviction to perform the behaviour.

This framework has been applied in various research projects. For instance, it was used to develop novel child caregiver hygiene behaviour measures in a formative study in Kenya (Wodnik et al., 2018). However, the framework did not provide specific behaviour change techniques (BCTs) for intervention. The Behaviour Change Wheel (BCW), which is an overarching framework for the COM–B, is yet to develop specific BCTs for its intervention functions (Michie et al., 2011). Nevertheless, it provides a systematic analysis on how to make the selection of policies (Michie et al., 2011). The COM–B framework is more related to the World Bank and Sanitation Programme's FOAM (for handwashing) and saniFOAM (for sanitation behaviours) behaviour change frameworks, where opportunity, ability and motivation are the key components for behaviour change (Coombes & Devine, 2010; Devine, 2009). The saniFOAM framework emphasizes the sanitation behaviours to be promoted in a given population (Focus) through targeting specific behavioural factors that have been categorized as opportunity, ability and motivation (Devine, 2009). While the FOAM approach emphasizes the behavioural factors

(Opportunity, Ability and Motivation) that need to be targeted in a handwashing with soap campaign in a given population (Coombes & Devine, 2010). Thus, the saniFOAM and FOAM frameworks specifically focus on sanitation and handwashing with soap behaviours respectively.

2.9.2 The Behaviour Centred Design (BCD) Framework

The Behaviour Centred Design (BCD) framework scrutinizes the behaviour in its physical, biological, social and temporal context, and was developed to design and evaluate behaviour change interventions (Aunger & Curtis, 2016). This theory of change was formulated based on other existing theories such as the Reinforcement Learning Theory (Sutton & Barto, 1998), the Evolution of Behavioural Control (Aunger & Curtis, 2015b), the Anatomy of Motivation (Aunger & Curtis, 2013) and the Behaviour Settings Theory (Barker, 1968). The implementation of the BCD framework follows five sequential steps that include (Aunger & Curtis, 2015a):

1. **Assess:** this initial stage involves gathering what is already known about the targeted behaviour;
2. **Build:** It involves carrying out formative research with the study participants to fully understand the targeted behaviours in their context. It assesses and suggests the possible drivers to bring about change;
3. **Create:** This stage involves an innovative team that designs an intervention based on the information gathered from formative research;
4. **Deliver:** This is the actual delivering of the intervention using various methods of communication such as community events and household visits;
5. **Evaluate:** this final stage aims at assessing the impact of the intervention

It is recommended that following all these five steps in a behaviour change programme would lead to novel, creative and sustainable solutions to context specific behaviour change problems (Aunger & Curtis, 2016). In addition, the BCD theory of change aims to disrupt environmental settings, while creating surprise which results in the revaluation and performance of the recommended behaviour. Currently, the BCD model has been applied in various behaviour change interventions to promote handwashing with soap, food hygiene and post-operative exercise (Biran et al., 2014a; Doyle, 2016; Gautam et al., 2017a). Despite being robust, the BCD framework when applied in previous research work, did not provide an opportunity to utilize a broader ecological model approach to position individual behaviours within a multi-level causal framework; rather it exclusively focuses on individual-level factors that influence behavioural outcomes (McLeroy et al., 1988).

2.9.3 Integrated Behaviour Model for Water, Sanitation and Hygiene (IBM – WASH)

IBM is a WASH specific model that provides an integrated approach in designing interventions to promote water, sanitation and hygiene mostly in rural communities. It is an all-inclusive model since it has been developed from detailed analysis of existing models such as RANAS (Mosler, 2012), FOAM (Coombes & Devine, 2010) and SANIFOAM (Devine, 2009). Being inclusive, it attempts to fill the gaps left by other models by organizing factors that affect the behaviour in an ecological framework through three dimensions (i.e. psychosocial, contextual and technological dimensions).

Inclusion of psychosocial factors in the IBM model strengthens the understanding of behaviour factors that determine behaviour at an individual level. The importance of exploring psychosocial factors in a behaviour change programme have also been emphasized by other existing models such as the Health Belief Model (Rosenstock, 1974), Theory of Reasoned Action (Madden et al., 1992), Theory of Planned Behaviour (Ajzen, 1991), Social Cognitive Theory (Bandura, 1989) and RANAS model (Mosler, 2012). Through psychosocial factors, IBM presents factors at an individual level that influence community cohesion and social integration. This provides an opportunity to focus on other factors that influence behaviour at different levels in the community other than on the individual. Integration of technological factors in the IBM model enables the inclusion of hardware components of WASH in an intervention. The IBM model was successfully used to guide selection of candidate handwashing stations in urban and rural Bangladesh (Hulland et al., 2013). In the study conducted by Hulland et al (2013), the model informed thematic coding of interview transcripts and contextualized feasibility and acceptability of specific handwashing station designs. The IBM was also successfully used to identify factors affecting acceptance of an improved tool for household faeces management for children in rural Bangladesh (Hussain et al., 2017).

The contextual element of the IBM-WASH framework provides an opportunity for the inclusion of personal and other environment related factors affecting a particular behaviour in an intervention. This approach ensures that focus of the intervention should go beyond targeting behavioural factors at individual level; a scenario which was observed in most models reviewed during development of IBM e.g. RANAS (Section 2.9.4) (Mosler, 2012). It has been observed that models that incorporate a multi-level perspective do so only for psychological factors related to behaviour change leaving out contextual and technological factors (Figueroa & Kincaid, 2010). Application of these three dimensions makes the IBM a holistic and an inclusive model of behaviour change that targets all levels in the community.

The three dimensions of IBM-WASH framework operates on five levels, highlighted below and shown in Table 4 (Dreibelbis et al., 2013a).

1. **Societal/structural level**: includes all the organizational, institutional and cultural factors that influence performance of a given behaviour;
2. **Community level**: it refers to the physical and social environment of an area that have an influence in the performance of a given behaviour;
3. **Interpersonal/household level**: This focuses on individuals staying in a given locality and how they interact amongst themselves and how that shapes their behaviour;
4. **Individual level**: This refers to the inclusion of socio-demographic factors in the model and how they shape one's behaviour;
5. **Habitual level**: this directly relates with the individual level and assesses the fact that opportunities related to the performance of WASH practices are repeated several times in a day and this has an influence on habit formation.

Table 4: Integrated behavioural model for water, sanitation and hygiene (IBM-WASH) (Dreibelbis et al., 2013b)

Levels	Contextual Factors	Psychosocial Factors	Technology Factors
Societal/ Structural	Policy and regulations, climate and geography	Leadership/advocacy, cultural identity	Manufacturing, financing, and distribution of the product; current and past national policies and promotion of products
Community	Access to markets, access to resources, built and physical environment	Shared values, collective efficacy, social integration, stigma	Location, access, availability, individual vs. collective ownership/access, and maintenance of the product
Interpersonal/ Household	Roles and responsibilities, household structure, division of labour, available space	Injunctive norms, descriptive norms, aspirations, shame, nurture	Sharing of access to product, modelling/demonstration of use of product
Individual	Wealth, age, education, gender, livelihoods/employment	Self-efficacy, knowledge, disgust, perceived threat	Perceived cost, value, convenience, and other strengths and weaknesses of the product
Habitual	Favourable environment for habit formation, opportunity for and barriers to repetition of behaviour	Existing water and sanitation habits, outcome expectations	Ease/Effectiveness of routine use of product

Despite all this, the IBM-WASH framework is simple, adaptable and applies to a wide range of dimensions and levels that influence human behaviour. However, rigorous measurement of the factors and the application of measurement theory still remain a challenge within the model (Dreibelbis et al., 2013a).

2.9.4 The Risk, Attitude, Norms, Ability and Self – Regulation (RANAS) model

It is important that behaviour factors associated with the targeted behaviours for an intervention be well understood. Thus, contextual factors that maintain unhealthy behaviours in the targeted community must be clearly explored. Additionally, it is critical that inner factors that need to be addressed by an intervention in a behaviour change programme be well understood. In order to respond to these sentiments, the Risk, Attitude, Norms, Ability and Self - Regulation (RANAS) model of behaviour change may need to be applied in a behaviour change intervention (Mosler, 2012). During its development, the RANAS model incorporated a range of existing behaviour change theories which include the Health Belief Model (Rosenstock, 1974), Protection Motivation Theory (Floyd et al., 2000), Social Cognitive Theory (Bandura, 1989), the Theory of Planned Behaviour (Ajzen, 1991), and the Health Action Process Approach (Schwarzer, 2008). The use of the four steps outlined in Figure 10 enable a step by step quantitative assessment of behavioural factors that permits systematic identification of the factors to be changed and the selection of the corresponding behaviour change strategies. The four steps consist of the following (Contzen & Mosler, 2015b):

1. **Behavioural factors identification:** At this stage, behaviours to be changed and the population to be targeted are identified. After identifying the population group to be targeted, behaviours of interest can be identified through observations and interviews in formative research. Then information about contextual and psychosocial behavioural factors influencing the targeted behaviours is collected. Such information about the behavioural factors is allocated to the RANAS psychosocial factors summarized in the RANAS model of behaviour change. With the use of the RANAS model in classifying the psychosocial and contextual factors, it helps to ensure that all important factors are included
2. **Measure and determine behavioural factors:** A RANAS model based questionnaire is developed to measure the targeted behaviours and potential behavioural factors identified in Stage 1. This is followed by a doer/non-doer analysis to identify behavioural factors

influencing the behaviours. Thus, responses of those performing the behaviours (doers) are compared to those not performing the behaviours (non-doers). A significant difference between the two indicates that the behavioural factor under analysis influences the behaviour and has to be addressed by the behaviour change techniques (BCTs) to the change the behaviour.

3. **Design behaviour change technique:** With the use of a BCT catalogue within the RANAS model, BCTs corresponding to the behaviour under study are selected to be applied in the behaviour change strategy to bring the required change in behaviour. Importantly, BCTs in the catalogue have to be adapted to the local context. In addition, relevant channels of communication should be selected. Altogether, the selected BCTs and the suitable channels of communication form a behaviour change strategy.
4. **Implement and evaluate behavioural change strategies:** To measure the effectiveness of the behaviour change strategies, they are evaluated in a before – after control (BAC) trial. Thus, the same data collection tools (e.g. questionnaire and observation guide) are used before and after implementation of the strategy. In addition, the study includes a control group where the results from the implemented strategy are compared against. The control group ensures that changes in the behaviour which occurred independently of the implemented strategy are controlled.

   The realized differences in behaviour and behavioural factor scores before and after implementation of the behaviour strategy are calculated and a comparison is made with the control group. It is considered that the behaviour change strategy has been effective when the before – after difference is larger for the group that received the strategy compared to the control group.

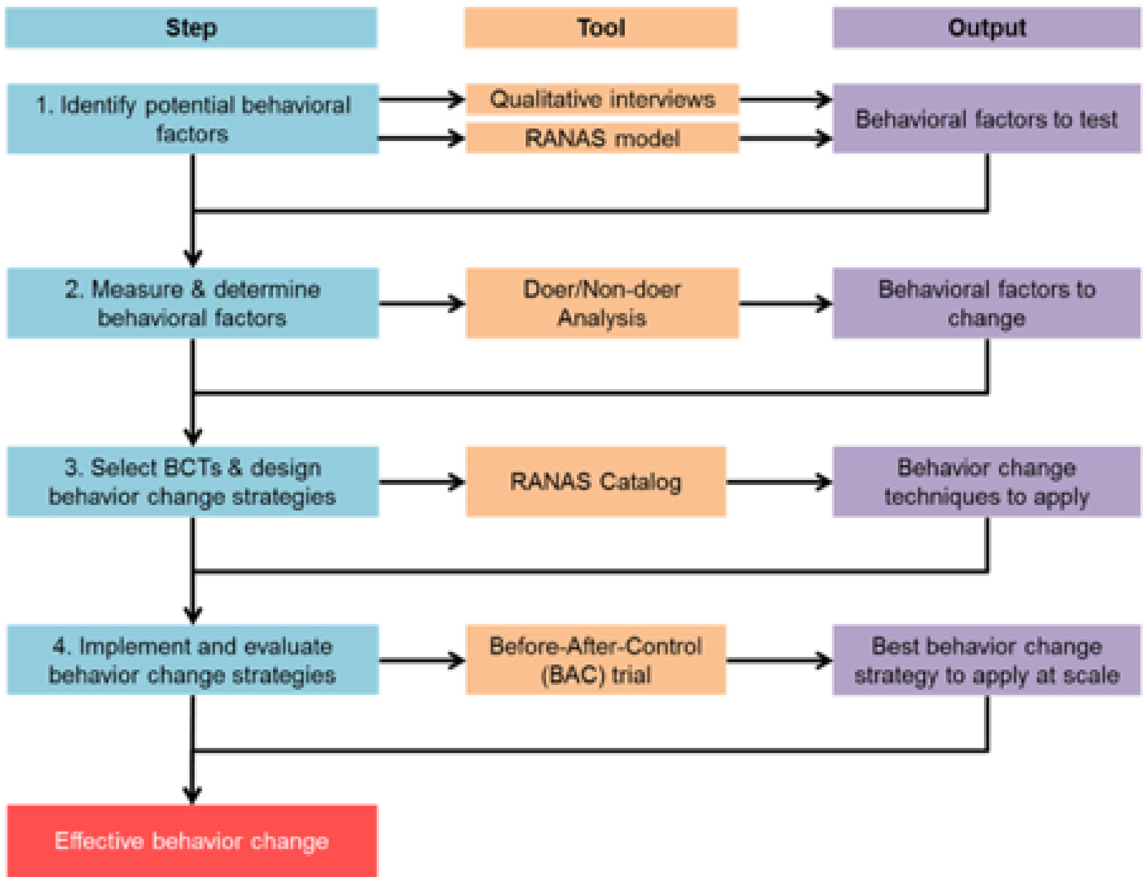

Figure 10: Steps of the RANAS approach (Contzen & Mosler, 2015b)

The RANAS model is therefore very effective during formative research to determine significant factors required to be addressed by a behaviour change campaign. Within the RANAS model there are the four key elements that are attained through the four steps highlighted in Figure 10 (Mosler & Contzen, 2016):

1. Psychosocial factor blocks

There are five psychosocial "factor blocks" that should be applied in a research study to determine behavioural factors that contributes to unhealthy behaviour in a study population (Figure 11).

The five factor blocks include:

A. **Risk factors:** This involves assessment of the participant's level of awareness about their exposure to disease causing organisms and preventive actions (i.e. factual knowledge), and perception of contracting a particular disease (i.e. perceived vulnerability) and the consequences of suffering from the disease (i.e. perceived severity). Previous research work has also shown the perceptions of individuals to disease risks (Floyd et al., 2000; Rosenstock, 1974; Schwarzer, 2008).

B. **Attitude factors:** The attitude factors addresses a participant's beliefs about the costs (e.g. time, money and effort) and benefits (e.g. high status) of a particular behaviour. It also includes the person's assessment of the positive and negative consequences of a behaviour. Included also are the feelings associated with the performance of the behaviour.

C. **Norm factors:** This includes a participant's perception about what behaviour is expected and performed in their society. This includes the behaviour of others such as household members and friends (i.e. descriptive norms), and others' approval or disapproval such as household members, relatives, community institutions, local leaders etc (i.e. injunctive norms). It also checks at the person's obligation to a particular behaviour (i.e. personal norm).

D. **Ability factors:** Ability factors check on a participant's capabilities to perform a particular behaviour (i.e. action knowledge). It also includes the person's confidence to perform the behaviour (i.e. self-efficacy), confidence to continue with the behaviour (i.e. maintenance – confidence in performance) and confidence to recover the behaviour (i.e. recovery – confidence in performance). The Theory of Planned Behaviour presents the attitude, normative and ability factors in relation to an individual's intention to execute a certain behaviour (Ajzen, 1991).

E. **Self–regulation factors:** The self–regulation factors include the participant's plan on how to maintain a certain behaviour. It also factors in the mechanisms on how to handle existing barriers to the performance of the behaviour.

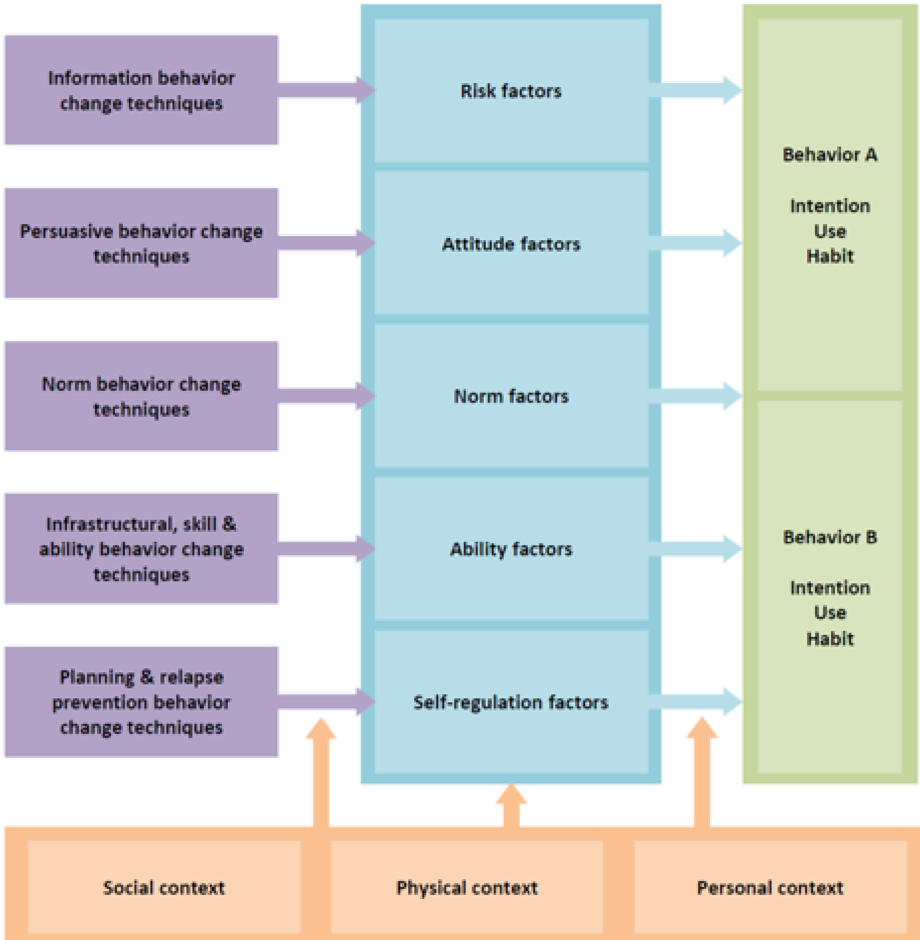

Figure 11: The RANAS model with the five block factors (Mosler & Contzen, 2016)

2. Contextual factors of the RANAS model

The contextual factors within WASH have been described as individual, setting and environmental factors that can influence behaviour change and adoption of new technologies (Dreibelbis et al., 2013a). Previous research has emphasized the importance of the interactions between individuals and their environmental setting (Bronfenbrenner, 1977; Gifford et al., 2011; Seimetz et al., 2016b). In the process of interacting with the household setting, individuals bring changes within their environment which later influences their behaviours. Thus, it has been concluded that behaviours and their behavioural factors that bring about performance of a behaviour are entrenched in contextual factors (Contzen & Mosler, 2015b). Furthermore, Contzen and Mosler (2015b) established that contextual factors can influence the behaviour by changing behaviour factors and may also alter the behavioural factors' influence on behaviour. In the RANAS model, the contextual factors have been categorised into social (e.g. policies and economic conditions), physical (e.g. built environment) and personal factors (e.g. age and education level).

3. Behavioural outcomes

Behavioural outcomes are the desirable or undesirable effects determined by the behavioural factors; behaviour "A" or behaviour "B" indicated in Figure 11. According to the RANAS model, the behavioural outcomes may be presented in three ways (Contzen & Mosler, 2015b):

a. **Behaviour:** the performance of a particular action. This includes both execution of healthy and unhealthy behaviours.
b. **Intention:** the willingness of a person to perform a particular behaviour.
c. **Habits:** These are established, repeated behaviours that are performed in frequently occurring circumstances and they are executed with less or without any cognitive effort.

4. Behaviour change techniques (BCTs)

BCTs are the actual activities in an intervention to address behavioural factors (i.e. smallest active components of a behaviour change intervention). Thus, they form the intervention strategy of a behaviour change campaign. It is recommended that BCTs should relate with behavioural factors that are significant between performers and non – performers of a particular behaviour (Contzen & Mosler, 2015b). Specific BCTs have been developed for each psychosocial factor block of the

RANAS model: information BCTs for risk factors; persuasive BCTs for attitude factors; norm BCTs for normative factors; infrastructural, skill, and ability BCTs for ability factors; and planning and relapse prevention BCTs for self–regulation factors.

2.10 Application of the RANAS model in WASH programming

To date, the RANAS model has been successfully used in a number of WASH related formative and intervention research projects. For instance, the RANAS model has been used to promote access to safe water in the households of LMICs (Friedrich et al., 2017; Huber & Mosler, 2013; Lilje et al., 2015; Slekiene & Mosler, 2018). The application of the RANAS model revealed the psychosocial and contextual factors that influenced cleaning of water containers to avoid drinking water recontamination in rural Benin where the type of container, commitment, forgetting and self-efficacy were identified as important factors influencing cleanliness of containers (Stocker & Mosler, 2015). Similarly, the RANAS model helped to identify behavioural factors related to solar water disinfection (SODIS) in Bolivia (Heri & Mosler, 2008), hygiene behaviour and SODIS uptake in Kenya (Graf et al., 2008), and the persuasion factors influencing the decision to use sustainable household water treatment in Zimbabwe (Kraemer & Mosler, 2010). In Chad, the model successfully identified the behavioural factors and helped in the designing of an effective intervention to improve household drinking water disinfection practices (Lilje et al., 2015; Lilje & Mosler, 2018).

The RANAS model has also been used to promote hygiene behaviours. In Zimbabwe, application of the model significantly identified the psychosocial and contextual factors related to effective handwashing techniques and provided recommendations for interventions (Friedrich et al., 2017). In another study, the RANAS model was used to identified behavioural factors for interventions to increase handwashing practices among school going children in Burundi and Zimbabwe (Seimetz et al., 2017). Sanitation campaigns in Malawi and Ebola prevention strategies in Gambia have also been promoted using the RANAS model (Gamma et al., 2019; Slekiene & Mosler, 2018). Despite the use of the RANAS model in various WASH related studies, to the author's knowledge, the RANAS model has never been used to identify behavioural factors and aid in designing an intervention to improve household food hygiene behaviours.

2.11 Relevance of the RANAS model in the current study

In the current research, the RANAS model, with clearly outlined steps, was used to provide procedural guidance during formative research, designing, and testing of a food hygiene intervention. In addition, the RANAS model provided guidelines that were used when formulating data collection tools for identifying behavioural factors. Furthermore, it provided a rigorous measurement of the identified behavioural factors between the doers and non-doers of the healthy behaviours to be implemented. The RANAS model's core asset is that for each identified behaviour factor it depicts specific BCTs that are thought to change exactly this factor for the intervention mapping.

The RANAS model has been identified as one of the few that is intended to be applicable across multiple WASH practices and interventions and associates specific intervention strategies with each of the identified factor blocks: information interventions with risk factors; persuasive interventions with attitudinal factors; infrastructural and ability interventions with ability factors

(Dreibelbis et al., 2013a). Thus, the RANAS model constitutes a solid basis for a theory and evidence-based intervention selection and development.

2.12 Behaviour change and its relevance on food hygiene

The performance of a particular behaviour can have an influence on an individual's own health and that of others (Mark & Paul, 2005). The performance of such behaviour is complex, as it depends on a number of constructs. Thus, changing an individual's behaviour is a process that requires change in specific behavioural factors (including contextual and psychosocial factors) that predict human behaviour in a given setting such as attitudes, norms and self-regulation attributes (Huber & Mosler, 2013). It should be noted that each behaviour is determined by different unique factors, and thus each set of behaviours require its own set of explanatory constructs (Mark & Paul, 2005). Previous research in food hygiene focused much on measuring microbial contamination in food, with little attention to the development of tailor made food hygiene behaviour change interventions (Ehiri et al., 2001a; Imong et al., 1995a; Iroegbu et al., 2000; Schmitt et al., 1997; Taulo et al., 2008, 2009). As such, the limited research that developed and tested food hygiene behaviour change interventions (Islam et al., 2013; Monte et al., 1997; Sheth & Obrah, 2004; Touré et al., 2013) focused on increasing the level of knowledge, as well as provision of WASH infrastructure, and did not address psychosocial factors that are integral to the performance of the behaviour. To bring about behaviour change, and considering that hygiene is determined by a wide range of factors, it is important to understand specific behaviours responsible for the contamination of food at household level. In addition, factors (e.g. contextual and psychosocial factors) for the performance of such behaviours should be explored to understand why the communities perform particular food hygiene related behaviours. Such an assessment provides the basis for the development of subsequent effective behaviour change interventions (Contzen & Mosler, 2015a).

2.13 The need for transformative WASH

The large new research trials of unprecedented scale and cost (i.e. The WASH Benefits and SHINE studies) reported no impact of a range of WASH interventions on the incidence of diarrheal disease, despite extensive formative research to inform and support the development of the intervention content and delivery (Mbuya et al., 2015; Null et al., 2018). However, the WASH Benefits study in Bangladesh did demonstrate a small reduction in diarrhea, albeit with evidence that there was no benefit from a combined WASH intervention over individual sanitation or hygiene programs (Luby et al., 2018a). This may be attributed to a number of factors, including the large number of pathways in which children may become exposed to diarrheal disease pathogens. Studies have demonstrated the potential role of food contamination in diarrheal disease transmission, particularly complementary foods, which have been found to have higher levels of contamination than drinking water (Kung'u et al., 2009; Lanata, 2003; Sheth et al., 2000; Taulo et al., 2008; Touré et al., 2011b).

Attempts to model the complex mechanisms that potentially link poor sanitation and hygiene to diarrheal disease, enteric enteropathy, under nutrition, and child development, highlight the challenges of understanding the myriad of environmental transmission routes and sources of contamination, which may contribute to diarrheal and other related diseases (Curtis &

Cairncross, 2003a; Roche et al., 2017; Unicef/WHO, 2009). All this calls for transformative WASH, in so much as it encapsulates the guiding principle that – in any context – a comprehensive package of WASH interventions (i.e. food hygiene inclusive) is needed that is tailored to address the local exposure landscape and enteric disease burden to achieve a major impact on child health (Cumming et al., 2019).

Chapter 3

Formative research

3.1 Rationale

This chapter provides details about the study area and describes the overall research methods. It further highlights the formative research presented in the form of two articles published in peer reviewed journals (Section 3.7 and 3.8). The formative research was conducted in two stages to inform the design of the food hygiene intervention. The first stage examined in detail the practices and associated behavioural factors at household level related to food safety which may be contributing to childhood diarrhoea. This was achieved using a hazard analysis critical control point (HACCP) approach to examine the flow of the preparation, storage and feeding of main complementary foods, with the aim of understanding the local context in which child feeding, food preparation and storage take place. The second stage examined the behavioural factors associated with these critical behaviours using the RANAS model described in

Chapter 2.

3.2 Study setting: Malawi

3.2.1 Geographical location

Malawi, a landlocked country, is located in south east Africa and shares boundaries with Zambia in the west, Tanzania in the north and Mozambique in the east, south and south west. Malawi is 901 km long, 80 to 161 km wide and has an area of 118,484 km^2, of which 80% (94,726 km^2) is covered by land, while the remaining 20% (24,404 km^2) are water bodies (mainly Lake Malawi) (Government of Malawi, 2011). The country is divided into three regions (i.e. Northern, Central and Southern region), containing 28 districts (Figure 12).

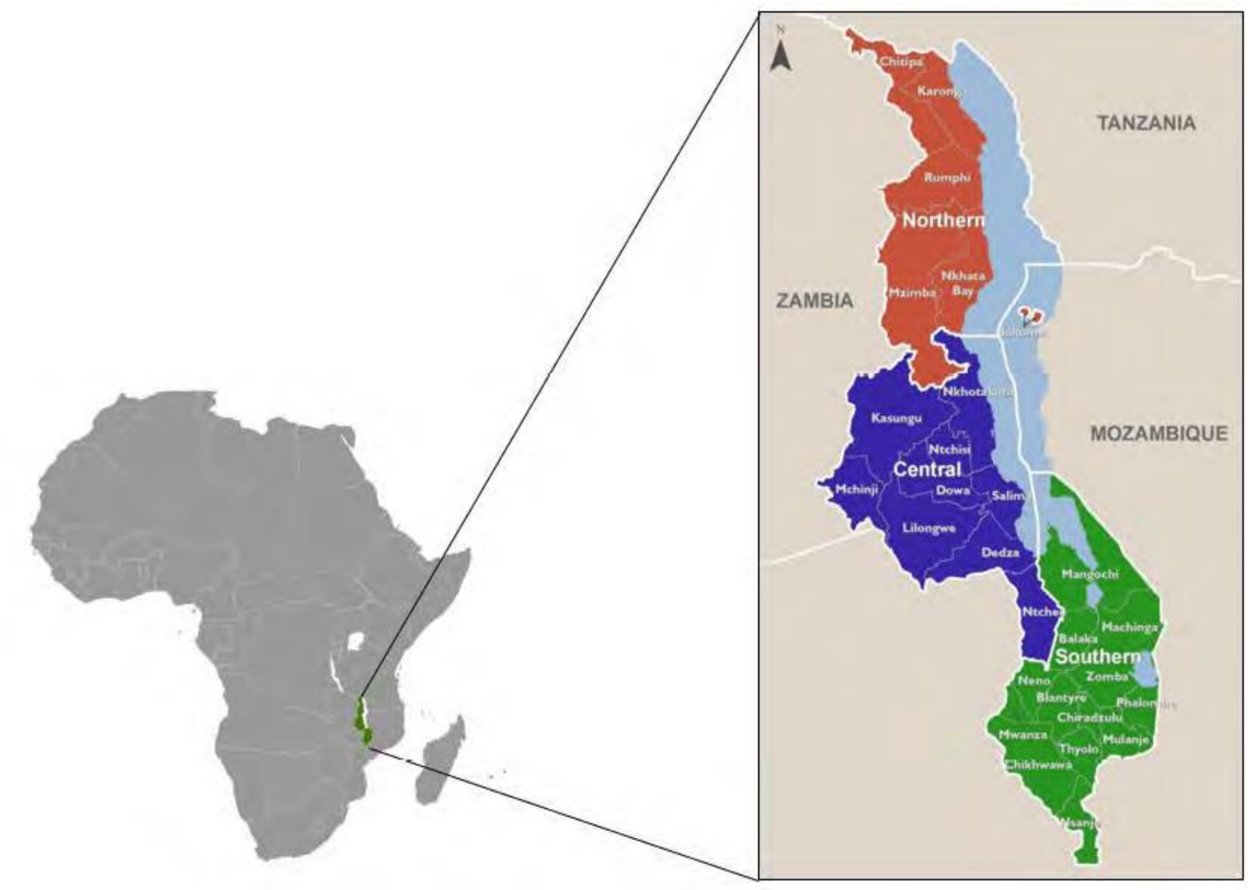

Figure 12: Map showing the position of Malawi in Africa, including the three regions of Malawi and the 28 districts (Msiska and Nielsen, 2019)

The Southern region has 13 districts, while the Central and the Northern regions have 9 and 6 districts respectively. Each district is divided into Traditional Authorities which are led by a Chief. The Traditional Authority (TA) is subdivided into villages which are led by Village Headmen (Government of Malawi, 2011).

3.2.2 Economy of Malawi

Malawi has been ranked as one of the poorest countries in the world. In 2016, 69.6% of Malawians (mainly from rural areas) lived below US$1.90 a day (IMF, 2017), with little to no improvement since 2010 (70.9%) (World Bank, 2019c). The per capita income for the country is at US$320, which is far from the World Bank's vision of achieving US$1000 in 2020 (IMF, 2017). The backbone of Malawi's economy depends on agriculture, which represents about 80% of the population and contributes to almost 30% of the Gross Domestic Product (GDP) through exports, of mainly tobacco, tea and sugar, that comprise 85% of Malawi's domestic exports (Government of Malawi, 2011). Since the country's economy depends on agriculture which is primarily rain fed, it experiences instability due to natural disasters such as long dry spells and periods of heavy rain. In addition, inadequate financial resources and unstable macroeconomic environments, associated with high inflation and interest rates, consistently derail the national economy (IMF, 2017).

Economically, overdependence on agriculture puts Malawi below average when compared to other countries in the sub Saharan region that depend on foreign aid (IMF, 2019). Similar to other low income countries, Malawi greatly depends on foreign aid for its recurrent transactions and development agenda. Between the period 2000 to 2017, Malawi had received about US$1.515 billion from donor partners such as the World Bank and European Union (World Bank, 2019b).

The country's development is guided by the Malawi Growth and Development Strategy (MGDS), a series of five-year plans that contribute to the long-term goals outlined in Malawi's development roadmap of Vision 2020 (Afidep, 2019). The current MGDS, version III, Building a Productive, Competitive and Resilient Nation, will run through to 2022 and focuses on education, energy, agriculture, health and tourism (UNDP, 2018).

3.2.3 Population statistics and Ethnic groups

According to the Malawi Population and Housing Census of 2018, the national population is 17,563,749, a 35% increase from 2008, representing a 2.9% per annum intercensal growth rate (Government of Malawi, 2018d). The increase in population has the potential to create high demand for resources including WASH access and food security, leading to an increased vulnerability among women, children, persons living with disability, and other groups affected by natural disasters and other emergencies (Government of Malawi, 2018b). Forty four percent of the population reside in the Southern region, while 43% live in the Central region and 13% in the Northern region. In terms of religion, the majority of the Malawian population are Christian (83%), followed by Muslim (13%), while 2% belong to other religions, and the remaining 2% do not belong to any religion (Government of Malawi, 2018d).

It is reported that 88% of Malawi's population use firewood as the source of energy during cooking (Government of Malawi, 2018d). Furthermore, cooking is done in separate buildings in

60% of households. According to the 2016 Demographic and Health Survey, overall, 11% of Malawians are connected to electricity; only 4% of the population in rural areas are connected to the national electricity grid compared with 49% in urban areas. Earth or sand is mostly used to floor households in rural areas (83%), while cement is commonly used to floor urban households (71%) (Government of Malawi, 2016).

According to the 2018 national census, it has been reported that the majority (84%) of the Malawian population live in rural areas, with only 16% residing in urban locations (Government of Malawi, 2018d). Additionally, more females (7,644,147) live in rural areas compared to males (7,136,238). Slightly more than half (51%) of the Malawian population is aged 18 years or under. Importantly, about 15% of the population are young children aged between 0 – 4 years old. Thus, Malawi's population is mostly young, requiring significant support and resources for its development and survival (Government of Malawi, 2018d).

In terms of households, Malawi has 3,984,929 households, 39% more than reported in 2008 (Government of Malawi, 2018d). However, the average household size has decreased from 4.6 to 4.4 persons per household in the same period (Government of Malawi, 2018d). This may imply that Malawians are slowly embracing family planning methods to control their family sizes which is directly linked to an increase in literacy rate from 64% to 69% between 2008 to 2018 (Government of Malawi, 2008, 2018d).

Over the last 15 years, Malawi has experienced an improvement in life expectancy from 45 in 2000 to 63 in 2017 (World Bank, 2019a). Improvements have also been recorded in other health indicators. For instance, child mortality in Malawi has decreased from 183/1000 to 65/1000 births over this time period (WHO et al., 2019). However, the increase in population growth being experienced in Malawi potentially masks the benefits associated with improved health indicators since the demand for health services keeps on increasing.

3.2.4 Malawi Water Sanitation and Hygiene (WASH) Services

In Malawi, the administration of WASH services is under the Directorate of Water and Sanitation in the Ministry of Irrigation and Water Development (MoIWD), Government of Malawi. The services are administered in collaboration with other key ministries such as the Ministry of Health (MoH); Education; Gender, Children, Disability and Social Welfare; and donor partners such as the World Bank, UNICEF, the United States Agency for International Development (USAID), and the British Government Foreign, Commonwealth and Development Office (FDCO). Implementation organizations such as WaterAid, World Vision International, United Purpose and Goal Malawi also play a major role in the delivery of WASH services at household and institutional level. Despite the MoIWD having overall responsibility for sanitation and hygiene governance, implementation of activities is primarily done by the MoH because it has a large network of extension workers (i.e. Health Surveillance Assistants) at grassroots level. This situation has created coordination challenges between the two ministries. For instance, collaboration challenges exist for the Malawi National Sanitation and Hygiene Coordination Unit (NSHCU), a Government body that technically coordinates national programmes. The MoIWD chairs this unit, while the MoH serves as its secretariat.

3.2.5 *Access to safe water in Malawi*

Ingestion of faecally contaminated water is an important route of transmission of a wide variety of bacterial, viral and protozoan enteric pathogens (Clasen & Cairncross, 2004; Quick et al., 2002). It has been previously reported that globally, 1.8 million childhood deaths from diarrhoea were associated with inadequate access to safe water in 2008 (Boschi-Pinto et al., 2008). Thus, the need for availability of safe water in household settings cannot be overemphasized.

Malawi made good progress towards attainment of the Millennium Development Goals in 2015 related to safe water coverage (Government of Malawi, 2014). However, at that time about 15% of Malawians still remained without access to safe water (Unicef & WHO, 2015). Access to safe water is higher among households in the urban areas (98%), compared to those located in the rural areas (85%), where piped tap water and boreholes are the common sources of water points, respectively. However, WHO/UNICEF Joint Monitoring reports that 69%, 20%, 9% and 2% in Malawi access basic, limited, unimproved and surface water respectively (WHO/Unicef, 2019).[2] In terms of water treatment, 22% and 33% of the households in urban and rural areas respectively treat their drinking water where chlorine/bleach is the most common method used (Government of Malawi, 2011, 2016). The quantity of water used at household level for various domestic activities is an important parameter that influence hygiene practices and therefore

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[2] **Basic**: Drinking water from an improved source provided collection time is not more than 30 minutes for a roundtrip including queuing
Limited: Drinking water from an improved source where collection time exceeds over 30 minutes for a roundtrip to collect water, including queuing
Unimproved: Drinking water from an unprotected dug well or unprotected spring
Surface water (No service): Drinking water collected directly from a river, dam, lake, pond, stream, canal or irrigation channel

public health (Howard & Bartram, 2003). Thus, it is important to ensure that households in rural settings of Malawi have adequate quantities of good quality water to ensure that they are free from diarrhoeal diseases, as well as skin and eye infections (Cairncross & Feachem, 1993). The quality of water for drinking and for other domestic purposes (e.g. preparing food) plays a significant role in the transmission of diarrhoeal diseases (WHO, 1993). In Malawi, Uganda and Ethiopia, it has been established that 21% of boreholes are contaminated with faecal matter which compromises public health since boreholes are the major source of water amongst the rural communities in these countries (Lapworth et al., 2020).

3.2.6 Access to sanitation in Malawi

Human excreta presents great risk to human health since a gram of fresh human faeces can contain about 10^6 viral pathogens, 10^6–10^8 bacterial pathogens, 10^4 protozoan cysts or oocysts, and 10–10^4 helminth eggs (Feachem et al., 1983). As such, access to improved sanitation can reduce diarrhoeal diseases by 32% - 37% (Esrey et al., 1991; Waddington & Snilstveit, 2009). Furthermore, it reduce rates of Trachoma and Ascariasis by 27% and 29% respectively (Esrey et al., 1991). Previous research has indicated that poor sanitation is indirectly linked to acute respiratory infections among malnourished children in LMICs (Schmidt, Cairncross, et al., 2009). Diseases arising from poor sanitation have been associated with poverty and account for about 10% of the global burden of diseases (Prüss-Üstün et al., 2008).

Access to improved sanitation in Malawi is suboptimal. It has been reported that 87% of Malawian households have a toilet facility (Figure 13). However, only 41% of the Malawian population has access to an improved toilet facility, while 6% has no access to sanitation (Government of Malawi, 2019, 2020b). Furthermore, the majority of households in rural Malawi construct traditional latrines with a lifespan of less than 12 months which calls into question the sustainability of open defecation free (ODF) status in rural villages (Unicef, 2015). Lack of access to basic sanitation facilities has the potential to create an environment where community members are forced to practice open defaecation, a situation which increases the risk of transmitting diarrhoeal diseases including cholera (Galan et al., 2013). The Malawian Government is committed to improving sanitation access among all Malawians. In order to achieve this, it has been implementing Community Led Total Sanitation (CLTS), which is a participatory approach to improve sanitation and hygiene behaviours. The CLTS approach was proven to rapidly improve sanitation coverage in Asia and some countries in Africa (Kar & Chambers, 2008). In Malawi, only four out of 28 districts have been declared ODF under the CLTS programme (Government of Malawi, 2020b), and reports indicate that most ODF communities gradually slip back to open defecation at an average rate of 10 per cent per year, suggesting significant losses over time (Bongartz et al., 2016). Improved sanitation has the potential to improve environmental faecal (i.e. from human and animal) contamination, which has been associated with malnutrition and child health (Waddington & Snilstveit, 2009). Thus, potentially contaminated environments in Malawi could affect child growth and development. This calls for more effort and efficient delivery of WASH behaviour change strategies to achieve long lasting sustained improvements.

3.2.7 Hygiene practices in Malawi

Previous research has emphasized how handwashing with soap at critical times can reduce diarrhoeal prevalence by 30% in a given population (Curtis & Cairncross, 2003a; Ejemot-Nwadiaro et al., 2015). Furthermore, use of running water with soap for handwashing is a key indicator for good hygienic practice at household and institutional level (Curtis & Cairncross, 2003). Nevertheless, coverage of handwashing facilities in Malawi remains low (36%), with the presence of water and soap in the available handwashing facilities being even lower at 11% (Figure 13) (Government of Malawi, 2020b).

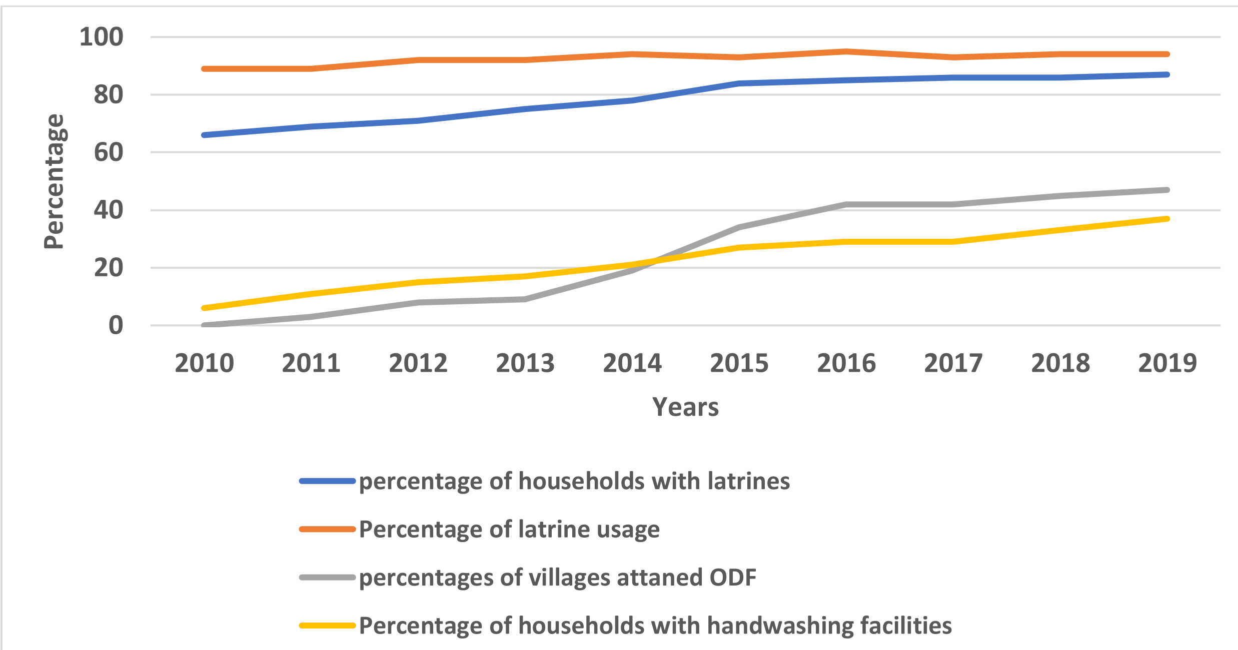

Figure 13: Malawi WASH data for a decade (Government of Malawi, 2020a)

3.2.8 Food hygiene practices at a Malawian household

In 1989, a detailed study was conducted which provided noticeable evidence that childhood diarrhoea in LMICs could be associated with contaminated food (Ersey & Feachem, 1989), which was substantiated by Lanata (2003) who documented that food could be more important than water in the transmission of diarrhoeal pathogens in low income countries (Lanata, 2003). More recently, in 2010, the WHO reported that foodborne agents caused about 420,000 deaths globally (WHO, 2015b), with 18 million DALYs (Disability Adjusted Life Year) being attributed to foodborne diarrhoeal disease globally (WHO, 2015b). A previous study conducted in rural Malawi showed that post-cooking activities which include improper handling of kitchen utensils, prolonged storage of left-over food at ambient temperature (with no or inadequate reheating) and poor handwashing practices, were risk factors associated with diarrhoea-causing pathogens in food (Taulo et al., 2008, 2009). In addition, animals were kept in the same room where leftover food was stored, which has been associated with contamination of the food (Brinkman et al., 1999; Ryan et al., 1996).

Taulo *et al* (2008 and 2009) investigated bacterial transfer to cooked thick porridge via ladles and hands during serving in 29 households in Lungwena, rural Malawi. The results showed that hands of household members preparing food became contaminated with *E. coli* and *S. aureus* cells in the range 0.6–3.7 and 2.2–4.3 $\log_{10}$ CFU/cm^2, respectively, following washing with contaminated water. Ladles became contaminated with 0.9–3.2$\log_{10}$ CFU/cm^2 of *E. coli* cells whereas contamination with *S. aureus* on ladles ranged between 1.9 and 4.6 $\log_{10}$ CFU/cm^2. Bacterial transfer from hands to food ranged from <1 to 3.6 $\log_{10}$ CFU/g for *E. coli* and 2.1 to 4.2 $\log_{10}$ CFU/g for *S. aureus*. Ladle surfaces transferred from 1.3 to 3.1 and from 1.2 to 4.3 $\log_{10}$ CFU/g of *E. coli* and *S. aureus*, respectively, on to the food. Contamination of food by hands was significantly ($p < 0.05$) higher than that of ladles and transfer of *S. aureus* was significantly ($p < 0.05$) higher than that of *E. coli*. The amount of bacteria transferred to the recipient depended on the wash water type and bacteria type. The study showed that although the traditional cooking of food deactivates *S. aureus* and *E. coli*, the porridge can be contaminated with bacteria during consumption using hands and serving on to a plate with wooden ladles.

Disposal of child faeces in Malawi has been linked to environmental contamination (Grimason et al., 2000), which potentially can contaminate the household food, especially given that open defecation is mostly practiced by children compared to adults (Pickering et al., 2015). Relatedly, children tend to have a higher prevalence of diarrheal disease and soil-transmitted helminth infections, and thus, their faeces may contain higher levels of pathogens and helminth eggs (Brown et al., 2013). Improper handling or disposal of young children's faeces has been associated with a 23% increased risk of diarrhoea [risk ratio (RR) = 1.23, 95% confidence interval (CI) 1.15–1.32] (Gil et al., 2004). All this advocates for the need to design context appropriate low cost food hygiene interventions to promote household food hygiene behaviours in rural settings of LMICs including Malawi.

3.2.9 Overarching policies for Water, Sanitation and Hygiene in Malawi

Compromised quantity and quality of water supply and sanitation services increases the risk of water and sanitation related diseases which contribute to poor health, loss of productivity and exacerbation of poverty (Mara et al., 2010). This situation also increases the risk of childhood diarrhoea which remains high in Malawi; 22% of reported cases in 2016, a slight increase from 2010 (17.5%) (Government of Malawi, 2011, 2016). Nevertheless, since the early 1990s, Malawi has been implementing strategies to improve WASH services at all levels. For instance, Malawi has developed a series of WASH related legal Acts, strategies and policies that support the implementation of WASH programmes as shown Table 5. The development of such documents was steered by international guidelines on WASH such as the Alma Atta Declaration of 1978 (WHO, 1978), the Ottawa Charter of 1986 (WHO, 1986), the EThekwini Declaration of 2008 (Water and Sanitation programme, 2008), the Istanbul Programme of Action for Least Developed Countries (2011–2020), the Millennium Development Goals (MDGs) (UNDP, 2015) and the Sustainable Development Goals (SDGs) (UNDP, 2016).

Table 5: Water, Sanitation and Hygiene related Acts, Policies and Strategies for Malawi

Acts of Parliament	**Policies**	**Strategies**
• **Public Health Act (1973) under review by Law Commission** • **Environmental Management Act (1996)** • **National Decentralization Act (1997) -Council bye-laws** • **Water Works Act (2005)**	• National Decentralization Policy (1995) • National Water Policy (2005) • National Water Policy (2005) • National Sanitation Policy (2008) • National Health Policy (2012) • National School Health and Nutrition Policy (2013) • National Environment Policy (2014) • National Environmental Health Policy 2019	• Malawi Water Sector Investment Plan (2012) • National Sanitation and Hygiene Strategy 2018 – 2024 • National 10 Year Sanitation and Hygiene Investment Plan and Strategy (2012 – 2022) • National Health Sector Strategic Plan (2017 – 2022) • National Community Health Strategy 2017 – 2022

In line with the Sustainable Development Goals (SDGs), the Government of Malawi produced the Malawi Growth and Development Strategy III (MGDS) (2017 – 2022) which has included specific WASH targets for a period of five years (UNDP, 2018). In support of the WASH targets highlighted in the MGDS III is the National Sanitation and Hygiene Strategy (2019 – 2024) which aims to ensure a healthy environment for human dignity, privacy, rights, and improved quality of life for all always and everywhere in Malawi by 2030 (Government of Malawi, 2018c).

The Malawi WASH related Acts, policies, strategies, and programmes highlight the commitment from the Malawi Government to improve WASH through investments, research and engagement in innovative solutions in sectors like health, agriculture and WASH to improve food security, health and people's well-being. The documents also highlighted Malawi's obligation to implement the SDGs of which water and sanitation for all (SDG 6), health and well-being (SDG 3), and food security and improved nutrition (SDG 2) are to be addressed.

As highlighted in the National Sanitation and Hygiene Strategy (Government of Malawi, 2018c), the Government of Malawi affirmed its commitment to WASH improvement through establishment of the following WASH targets that align with the SDGs (i.e. SDG 3: health and well-being and SDG 6: water and sanitation):

- Increase the percentage of households with improved sanitation access (climbing the sanitation ladder) from the current 13.8% to 75% by 2030
- Increase Open Defecation Free (ODF) coverage from 41.7% to 90% by 2030
- Increase the number of people accessing safe water supply from 83% to 90% by 2030
- Increase the percentage of households using hand washing facilities with soap from 10.5% to 75% by 2030

However, Malawi faces numerous challenges to achieving access to WASH for all by the year 2030. For example, the provision of only 0.03% of the total annual budget from the Government of Malawi is inadequate to support WASH initiatives (Government of Malawi, 2020b). Currently, 80% of the WASH financial resources come from the donor partners. This demonstrates the government's failure to meet its commitment on the eThekwini Declaration (2008) which requires African Governments to spend at least 1.5% of their GDP on WASH (WaterAid, 2016a). The available funding is mostly channeled to the improvement of water supply, with little resources assigned for sanitation and hygiene (WaterAid, 2016b). Furthermore, WaterAid (2016) highlighted unequal distribution of WASH infrastructure, lack of proper leadership organization for WASH, unreliable water supply, poor coordination and integration among WASH stakeholders and limited capacity by the civil society and non-governmental organizations (NGOs) to achieve real change in the sector.

Though WASH, food security and nutrition have been prioritized in some commitments from the Government of Malawi, food hygiene has not been incorporated adequately. This concurs with findings of studies indicating that the food contamination pathway has not been adequately addressed, and is an overlooked opportunity in WASH, nutrition and health (Gautam et al., 2017a; Humphrey et al., 2015; Motarjemi, 2000; Touré et al., 2013).

3.2.10 Nutrition and food safety related policies in Malawi

The current Malawi National Multi-Sector Nutrition Policy 2018–2022 (Government of Malawi, 2018a) has been developed following the review of the first National Nutrition Policy and

Strategic Plan 2007–2012 (Government of Malawi, 2007). The 2018 – 2022 policy intends to provide a guiding framework for the successful implementation of the national nutrition response; address the existing and emerging national and global issues; and consequently, uphold the Government's commitment towards eliminating all forms of malnutrition. The following strategies were included to be used in the implementation of the policy: National Nutrition Education and Communication; Infant and Young Child Feeding (IYCF); Micronutrient; Adolescent Nutrition; School Health and Nutrition; Early Childhood Development; Community-based Management of Acute Malnutrition (CMAM); Nutrition Care Support and Treatment (NCST); and Prevention and Treatment of Nutrition-Related Non-Communicable Diseases (NCDs). The Policy has identified eight priority areas which include: i) prevention of undernutrition; ii) gender equality, equity, protection, participation and empowerment for improved nutrition; iii) treatment and control of acute malnutrition; iv) prevention and management of overweight and nutrition-related NCDs; v) nutrition education, social mobilization, and positive behaviour change; vi) nutrition during emergency situations; vii) creating an enabling environment for nutrition; and viii) nutrition monitoring, evaluation, research and surveillance.

Review of both the current (2018 – 2022) and previous (2007 – 2012) policies revealed that issues of WASH and food hygiene were not included highly prioritized compared to the nutrition specific interventions. This is evidenced by the lack of WASH and food hygiene on the list of priority areas. Much as WASH was included under the Malawi National Education Policy, context specific details on how it would be integrated with nutrition activities was not indicated. In addition, the Malawi

National Sanitation Policy (Government of Malawi, 2006) was not included on the list of national policies to be linked with nutrition programming.

Unlike nutrition, Malawi has no specific national food safety policy and strategies to coordinate roles and align activities to appropriate government departments (Morse et al., 2018). Lack of national food safety policy in Malawi is a clear indication that this sector has been lowly prioritized. For instance, despite that issues of nutritional quality and safety of food are inextricably linked, donor-driven responses to stunting and malnutrition has led to much stronger support for the nutrition sector, to the detriment of the food safety sector (Morse et al., 2018). The available policies and regulations (Table 6) related to food management systems for Malawi focuses on commercial food with little attention on household food safety and hygiene; and they have been described as weak, fragmented and lack proper coordination (FAO, 2015; FAO/WHO, 2005; Morse et al., 2018). Morse *et al* (2018) emphasized on the need to recognize household food safety and hygiene if significant progress is to be made in the reduction of the burden of foodborne diseases.

Table 6: Summary of main policies and legislation which affect food safety and quality in Malawi (Morse et al., 2018)

Current related food policies	Current Acts of parliament
Nutrition Policy (and strategy) 2018	Public Health Act 1948
National Alcohol Policy 2012	Malawi Bureau of Standards Act 1972:2012
National Fisheries and Aquaculture Policy 2012	Fisheries Conservation and Management Act 1997
Health Promotion Policy 2013	Meat and Meat Products Act 1976
National Quality Policy 2014	Milk and Milk Products Act 1971
National Agriculture Policy 2016	Pharmacy, Medicines and Poisons Act 1988
National Environmental Health Policy (draft)	Local Government Act 1998
	Hotels and Tourism Act 1968 (plus amendments)
	Iodisation of Salt Act 1995
	Consumer Protection Act 2003
	Competition and Fair Trade Act 1998
	Control of Goods Act 1968
	Business Licensing Act 2012

3.3 Chikwawa district

The research documented in this thesis (i.e. formative and intervention trial) was conducted in four out of 12 rural administrative traditional authorities (TAs) in Chikwawa district, located in the Southern region of Malawi (Figure 14). Three TAs were selected in collaboration with the District Coordinating Team (inter sectoral team that coordinates WASH activities at district level) based on the following factors: the geographic location (rural remote area), socio economic status (low income communities), access to safe water, status of the communities in terms of being declared ODF, and high diarrhoeal disease prevalence. The three TAs (i.e. Ngowe, Ngabu and Masache) which share geographical boundaries, served as the intervention areas, while a further TA (i.e. Maseya) located approximately 20km away from the intervention areas acted as the control. Formative research took place in the same TA as the intervention (to ensure household similarities), but amongst households not enrolled in the intervention implementation group.

The district is in a low-lying area and, therefore, prone to flooding in the rainy season. Similar to other districts of Malawi, Chikwawa has two seasons per year, that is, rainy/farming season that lasts from November to April and dry/off farming season from May to October. The district has an annual average temperature of 25.7^{0}C (14.1^{0}C minimum and 36.1^{0}C maximum) and an annual average rainfall of 797 mm (Climate Data Organization, 2018).

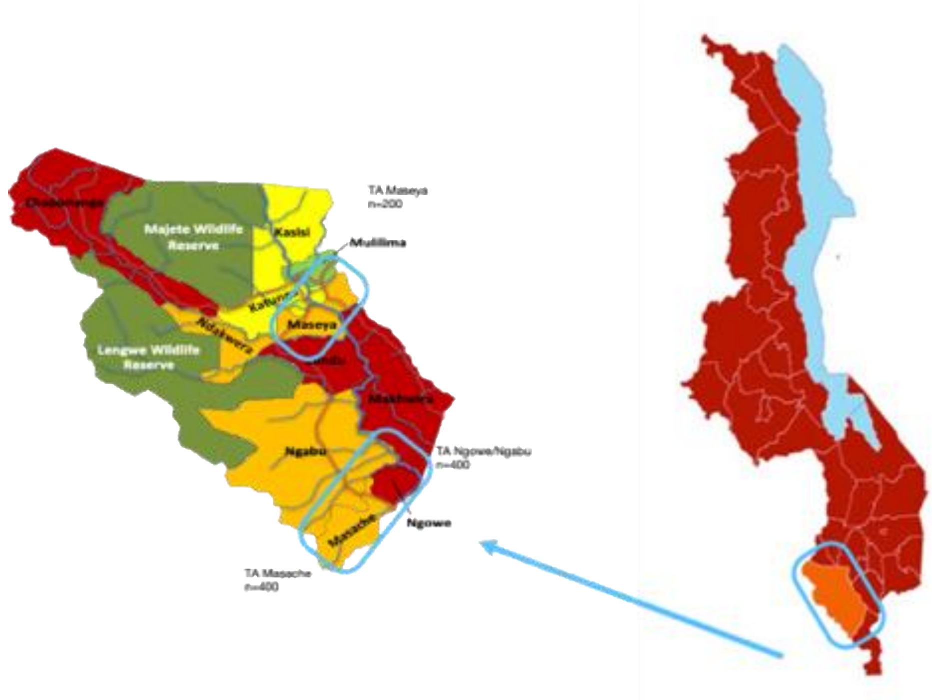

Figure 14: Map of Malawi showing the study location

Covering an area of 4755 km^2, the district has an estimated population of 518,287, of which 16% are under the age of five years, with an average of 4.4 people per household (Government of Malawi, 2014, 2016; Malawi National Statistical office, 2017). The District has an under-five mortality rate of 90 deaths per 1000 births compared to 85 at national level (Government of Malawi, 2016). Full vaccination coverage is 62.8%, which is higher than the national average (54%), however diseases, such as childhood diarrhoea, remain higher in Chikwawa (26.3%) than nationally (22%) (Government of Malawi, 2014, 2016). Acute respiratory infection rates among under five children are 9% (7.8% nationally). Seventy percent of children under six months were reported to be exclusively breastfed with 88.6% being introduced to solid foods after the recommended six months. Chikwawa remains one of the district where the highest rate of acute malnutrition in Malawi has been recorded (6.6% against national rate of 2.5%) (Unicef, 2016). Being rural, Chikwawa is one of the districts with the lowest literacy rate (58%) and ranks low on the economic indicator wealth index (Government of Malawi, 2019). Most of the households in the district earn their living through subsistence farming. Access to improved water sources in Chikwawa is 86.6%, however, improved sanitation coverage is 42.4% (Government of Malawi, 2016). Twenty four percent of the households have hand washing facilities, and only 10.7% of the households have hand washing facilities with soap and water available (Government of Malawi, 2016).

3.4 Overall research methods

A mixed method approach was applied in the implementation of this research (Leech & Onwuegbuzie, 2009). Mixed methods investigations involve integrating quantitative and qualitative data collection and analysis in a single study or a programme of inquiry (Hanson et al., 2004). The integration component of mixed methods add value to the research as it gives readers more confidence in the results and the conclusions they draw from the study (O'Cathian et al., 2010). This form of research is more than simply collecting both quantitative and qualitative data; it indicates that data will be integrated, related, or mixed at some stage of the research process. The underlying logic of mixing is that neither quantitative nor qualitative methods are sufficient in themselves to capture the trends and details of the situation. When used in combination, both quantitative and qualitative data yield a more complete analysis, and they complement each other to ensure validity and reliability of the collected data.

Mixed methods research builds on both quantitative and qualitative approaches. In the quantitative approach, the investigator relies on numerical data to test the relationships between the variables (Miro & Magangi, 2011). The researcher tests the theories about reality, looks for cause and effect, and uses quantitative measures to gather data to test the hypotheses. The researcher relates the variables to determine the magnitude and frequency of relationships. Quantitative studies are either descriptive or experimental. A descriptive study establishes associations between variables, while an experiment establishes probable causality. Hence, the goal of quantitative research is to describe the trends or explain the relationships between the variables. The sample size is large and is randomly selected from the larger population to be able to generalize the results to the population. The main quantitative designs include experimental, quasi- experimental, and correlational and survey research designs. To collect data for the study, the researcher identifies independent, dependent and control variables (Creswell, 2005) and collects the data using existing or pilot-tested, self-developed instruments intended to yield reliable and valid scores (Miro & Magangi, 2011).

In contrast to the quantitative approach, qualitative research approaches reality from a constructivist position, which allows for multiple meanings of individual experiences (Guba & Lincoln, 1988). In this approach a researcher develops a complex, holistic picture, analyses words, reports detailed views of informants, and conducts the study in a natural setting (Clark, 2008). The goal of qualitative research is to explore and under- stand a central phenomenon in a qualitative research study (Creswell, 2005). The research questions are general and broad, and seek to understand participant's experiences with the central phenomenon. The sample size is often small and purposefully selected from those individuals who have the most experience with the studied phenomenon (Patton, 1990). The major qualitative research designs include case study, phenomenology, grounded theory, ethnography and narrative research (Clark, 2008). The main types of qualitative data includes transcripts from individual and focus group interviews with participants, observations, documents about the studied phenomenon, audiovisual materials and artefacts(that is, material objects used by the people). Interpretation involves stating the larger meaning of the findings and personal reflections about the lessons learned (Guba & Lincoln, 1988).

In this study, both qualitative and quantitative methods were used to collect data during formative research and at end line evaluation. The two methods complemented each other to ensure validity and reliability of the collected data. Through this approach, a number of tools (highlighted in Chapter 3 and Chapter – **5**) were developed and used to meet the objectives of the study.

3.5 Conceptual frameworks of the study

The study applied two conceptual frameworks: 1). HACCP approach (Section 2.6) was applied during formative research to identify key critical control points for the improvement of food hygiene at household level. 2) The RANAS model (Section 2.9.4) was applied during formative research, implementation and evaluation of the trial. The RANAS model provided guidance in the identification of the behavioural factors and the corresponding behaviour change techniques (BCTs) that could be applied to the identified gaps (Mosler & Contzen, 2016). Consequently, it provided scientific guidance on which strategies to follow during the intervention. Because human behaviour occurs in an environmental setting where a number of factors come into play, understanding of psychosocial factors alone may not be enough to bring about behaviour change.

As such, this must be complemented with details of the contextual factors where the behaviour occurs and the RANAS model provided an opportunity for such understanding.

Section 3.7 and 3.8 are articles published in peer reviewed journals and they present key findings of the formative research in relation to the targeted food hygiene behaviours.

3.6 Risk Factors Associated with Feeding Children under 2 Years in Rural Malawi: (Paper 1)

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Elizabeth Tilley: (Co - Investigator)
Review and editing the manuscript

Rossanie Malolo: (Co - Investigator)
Field data collection supervision and reviewing the manuscript

Save Kumwenda: (Co - Investigator)
Review and editing the manuscript

Janelisa Musaya: (Co - Investigator)
Microbiological sample analysis and reviewing the manuscript

Tracy Morse: (principal supervisor)
Supervised and assisted with manuscript compilation, reviewing and editing

This section of the chapter 3 is an exact copy of the journal paper referred to above.

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Article

Risk Factors Associated with Feeding Children under 2 Years in Rural Malawi—A Formative Study

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Abstract: Diarrhoeal disease remains one of the leading causes of morbidity and mortality in the under-five population, particularly in low income settings such as sub-Saharan Africa. Despite significant progress in sanitation and water access, faecal-oral infections persist in these populations. Therefore, a better understanding of these transmission pathways, and how potential risk factors can be reduced within low income contexts is needed. This study, conducted in Southern Malawi from June to October 2017, used a mixed methods approach to collect data from household surveys (n = 323), checklists (n = 31), structured observations (n = 80), and microbiological food samples (n = 20). Results showed that food prepared for immediate consumption (primarily porridge for children) posed a low health risk. Poor hygiene practices increased the risk of contamination from shared family meals. Faecal and Staphylococcal bacteria were associated with poor hand hygiene and unhygienic eating conditions. Leftover food storage and inadequate pre-consumption heating increased the risk of contamination. Improvements in food hygiene and hand hygiene practices at critical points could reduce the risk of diarrhoeal disease for children under 2 years but must consider the contextual structural barriers to improved practice like access to handwashing facilities, soap, food and water storage.

Keywords: food hygiene; food safety; complementary food; child feeding; Malawi

1. Introduction

Diarrhoeal disease remains one of the leading causes of morbidity and mortality in the under-five population globally, with approximately 424,000 deaths annually [1]. The Malawi Demographic and Health Survey (2016) indicated that 22% of children under the age of five years had diarrhoea two weeks before the survey, a slight increase from the 17.5% reported in 2010 [2,3]. The high prevalence of childhood diarrhoea could be one of the contributing factors to the high under-five mortality rate (62 deaths per 1000 births) experienced in Malawi [2]. Primary sources of direct and indirect contamination have been clearly outlined in the F-diagram for decades [4], highlighting the key transmission routes for pathogenic organisms. Recent research undertaken in low income countries [5–9] has expanded on the F-diagram to better illustrate the links between under-five behaviours, daily activities, and faecal exposure. Several studies have now reported the significance of child play areas, mouthing, geophagia, animal contact, and water as potential sources of diarrhoeal disease transmission within these settings [10–14].

Previous studies have highlighted the important role of food hygiene in diarrhoeal disease prevention, a key but often neglected area of the F-diagram. However, significant numbers of pathogens have been isolated in complementary food in Sub-Saharan Africa, Bangladesh and Peru [15–18], most of which have been associated with prolonged food storage at high ambient temperature, seasonality, and unclean utensils [16–22]. In addition, studies have reported significant associations between diarrhoeal disease and lack of a kitchen, kitchen cleanliness, handwashing at critical times, feeding practices, waste disposal and storage of food on the floor [23–28]. Post-cooking activities that include improper handling of kitchen utensils, and poor handwashing practices are risk factors that have been associated with diarrhoea-causing pathogens in food in Malawi [29,30].

Diarrhoeal disease interventions have traditionally focused on water, sanitation and handwashing with soap (WASH), with little integration of food hygiene programmes [12]. Nevertheless, the contribution of food in the transmission of diarrhoeal disease has been clearly outlined by a 2015 WHO report which attributed 70% of the burden of foodborne disease to sub-Saharan African and South East Asia, with 40% affecting children under the age of five [31]. Despite rising evidence of the role of food in disease transmission, attempts to model the complex mechanisms which potentially link these to diarrhoeal disease, enteric enteropathy, under nutrition and child development are limited, primarily due to the myriad contributing factors [32–36]. Recent studies conducted in Nepal, Gambia and Mali have shown the potential impact of child caregiver training, follow-up and participatory approaches (including hazard analysis principles at household level) on the safety of domestically produced complementary foods [37–40]. Previous studies on diarrhoeal disease prevention conducted in Malawi indicated the importance of handwashing, water treatment and use of latrine in diarrhoea prevention [41,42]. However, few studies have explored child feeding practices and their potential effects on childhood diarrhoea in this setting.

Research has shown the need to apply the Hazard Analysis Critical Control Point (HACCP) strategy to identify hazards associated with complementary food preparation, handling, storage and child feeding practices, with subsequent identification of effective control points [19]. Although previous studies have contributed to our understanding of complementary foods as a source of pathogen transmission, most have focused specifically on the levels of microbial contamination in foods. There is still a need to understand cultural practices including how, when and what children under five are fed throughout the day, the other items they are mouthing, behavioural factors that contribute to caregiver actions, and the microbiological quality of foods provided across that time span. By assessing these potentially risky practices, we can assess cross-cultural similarities with other studies in the region, and provide a basis for developing effective interventions both regionally and locally to improve food hygiene practices. Therefore, the specific objectives of this paper were to: (1) identify practices and associated factors at household level related to food contamination, child mouthing, handwashing practices and kitchen utensils; and (2) develop a flow diagram of the preparation, storage and feeding of main complementary foods with the aim of understanding the local context in which child feeding, food preparation and storage take place. This study was a component of a larger body of work to understand potential infection pathways of children under the age of five years in an intervention trial to improve child health in rural settings of Malawi.

2. Materials and Methods

2.1. Setting and Population

This was a formative study undertaken in the Southern Region of Malawi in Chikwawa District from June to October 2017. Covering an area of 4878 km^2, the district has a population of 564,684, of which 16% are under the age of 5 years [2,43]. Full vaccination coverage is 76.4%, which is in line with national coverage (75.8%). Acute respiratory infections among under-5 children were 6% (5% nationally). 70% of children under 6 months were reported to be exclusively breastfed with 88.6% being introduced to solid foods after the recommended 6 months. Being rural, the Chikwawa district is one of the districts with the lowest literacy rate (65.2% young female and 70.4% young male) and ranks low on the wealth index indicators [2,44]. Access to improved water sources in Chikwawa is 86.6%. However, improved sanitation coverage is 42.4% [2]. Twenty-four percent of households have handwashing facilities, which is slightly higher than at the national level (19.5%). However, only 10.7% of households have handwashing facilities with soap and water, despite 44% of households having soap available for other needs within the home [2,44].

2.2. Recruitment and Participants

Malawi is divided into 28 Districts, which are subdivided into Traditional Authorities (TAs). Each TA contains villages, which are administered by chiefs and/or village heads. There are 12 Traditional Authorities (TAs) within Chikwawa district. This work was based in two TAs selected in collaboration with the District Health Office.

The number of households and population in the study area were obtained from the community health workers' (locally known Health Surveillance Assistants) register. Households were selected in the 4 stages of the study using systematic random sampling from the register. All participants in Stages 1, 2, and 4 were part of Stage 3 (Table 1). A sample size of 295 was calculated based on the Chikwawa district diarrhoea prevalence of 26.3%, with an acceptable error margin of 5% [44]. Taking into account non-responses and missing data, the sample size increased to 323.

Table 1. Stages of the data collection method.

Stage of Data Collection	Data Collection Method	Number
Stage 1	Checklist observations	31
Stage 2	Structured observations	80
Stage 3	Demographic and socio-economic questionnaire	323
Stage 4	24 h food sampling households	20

To ensure that there were no significant variations in access to water, all recruited households resided within a 500 m radius of a functioning protected borehole. Eligible households had a child aged between 3 and 24 months. The age of the children was verified through birth and/or immunization records supplied by the caregiver. Physical recruitment was conducted by trained research assistants with the approval and support of community health workers (Health Surveillance Assistants) and traditional leaders (village chiefs). Written consent was received from all households willing to participate before allocation of a household identification number and associated barcode. Pre-testing of all data collection tools was conducted to identify and eliminate irrelevant questions while key questions were further edited for easy understanding.

2.3. Observations

To identify critical control points for subsequent microbiological sampling, checklist and structured observations followed by in-depth interviews were used. Initially, checklist observations were conducted in 31 households that were selected from the list of recruited 323 households using systematic random sampling to identify a list of behaviours that were considered to put children at risk of developing diarrhoea. For the checklist observations, a household was visited over two consecutive days: 6 am–12 pm on the first day and from 12–6 pm on the second. The aim was to capture all events of interest that occurred in a day, including child mouthing (geophagia inclusive), practices around food storage, preparation and feeding/eating. In addition, the child caregiver's handwashing practices at critical times were observed: before food preparation, before child feeding/eating, after toilet use and after cleaning a child following defecation. "Child feeding practices" in this paper refers to complementary food given to the child after 6 months, including child self-feeding, while "child caregivers" include any household members, including parents, who are responsible for the daily care of the targeted child. Responsibilities of the caregiver include feeding and preparing the child's food, bathing, and assisting the child during defecation. Subsequent structured observations were conducted, specifically focusing on behaviours noted during checklist observations. In total, 80 households were targeted for structured observations (including those previously used for checklist observations) and visited once between 6 am and 1 pm. Checklist observations had indicated that the majority of food preparation and feeding events took place in the morning.

In-depth interviews followed each structured observation period to understand how and why some practices were conducted as observed. To ensure good quality data, debriefing sessions were conducted daily where supervisors and enumerators cross-checked observation forms to ensure that data were complete and consistent in reporting observed practices.

A team of 5 female observers (BSc holders in Social Sciences ($n = 1$) and Environmental Health ($n = 4$)) were trained to conduct in-depth interviews, checklist and structured observations. The training package included details of the research study, the theoretical science of observational research (Hawthorne effect inclusive) and observation tools. The research team opted for female research observers since child care at community level in Malawi is primarily performed by females.

2.4. Demographic, Socio-Economic and Hygiene Proxy Questionnaire

Following the observation stage, a structured questionnaire was conducted which contained closed questions and captured demographics, hygiene behaviours, child health status, and socio-economic proxy measures. At the end of the interview with the child's primary caregiver, enumerators conducted spot checks and recorded hygiene proxy measures such as the presence and condition of the latrine, the presence, location and type of handwashing facilities (including the availability of soap and water), the presence of a kitchen, and the presence of animals and their faeces. Face-to-face interviews were conducted in Chichewa, the local language of Chikwawa district. Behavioural factors for each of the critical areas were assessed using the RANAS (Risk, Attitude, Norm, Ability and Self-regulation) model [45,46]. The structured questionnaire was conducted by ten well-trained and experienced research assistants who were fluent in Chichewa.

2.5. Microbiological Sampling and Analysis

In total, 224 microbiological samples were collected over a 24 h period in 20 households selected from the list of 323 recruited households using systematic random sampling to assess the extent of bacterial contamination in foods consumed by target children. Households were visited on three occasions within 24 h for sampling, as outlined in Figure 1.

All sampling points in the study were informed by the observations which were conducted prior to sampling. The child's most frequently consumed foods were sampled for microbiological analysis. Sampled foods included the morning porridge, and nsima, which is the main meal for lunch and dinner. Both porridge and nsima are common complementary foods in Malawi prepared locally at home from maize, millet or sorghum flour. For porridge, the liquid is cooked for 30 min before adding sugar, salt, pounded ground nuts or milk depending on availability. The porridge was given to children after 10–15 min of cooling. Samples of porridge were taken in the morning after cooking and after serving (Figure 1). Porridge was served in a plate and eaten with a spoon, child's hands (self-feeding) or caregiver's hands.

Day 1: Visit 1	Day 1: Visit 2	Day 2: Visit 3
Between 12–2pm	**Between 5–6pm**	**Between 6–9 am**
• Relish after cooking • Relish after serving • Swab of plate	• Relish during storage (from lunch) • Relish after reheating • Relish after serving • Nsima after cooking • Swab: relish plate • Swab: Nsima plate	• Relish during storage (from previous day) • Relish after reheating • Relish after serving • Nsima during storage (from previous day) • Nsima after reheating • Porridge after cooking • Porridge after serving • Swab: porridge plate • Swab: feeding spoon

Figure 1. Summary of sampling plan for microbiological testing of foods consumed by targeted children.

Nsima is prepared just like porridge; however, more maize flour is added to produce a thicker consistency, which is cooked for approximately 40 min, and no other ingredients are added. Nsima is prepared for immediate consumption. However, we occasionally observed that it was kept longer, e.g., overnight, to be eaten the following morning. As such, nsima samples were taken during dinner after cooking, and the following morning from leftovers of nsima eaten during dinner (Figure 1). Nsima is served in a plate and eaten using hands with a relish (Scheme 1).

Scheme 1. Dishes of nsima and relish (beans) after serving in Chikwawa, rural Malawi.

Relish is the word used to describe the side dish that is served with nsima. The most common relishes recorded in the study were beans, vegetables and fish. Depending on availability, tomatoes, onions, salt and cooking oil were added to the relish and cooked together. The relish is cooked for between 45 and 180 min, after which it is cooled for 10–15 min before consumption. Relish is primarily cooked in the morning in large amounts ready for lunch so that it can be eaten during lunch, dinner and, sometimes, on the following day. Relish samples were collected at three main times: at lunch after cooking and after serving in a container (mostly plate); at dinner from a storage container, after reheating and after serving; and the following morning from a storage container, after reheating and after serving.

Another set of environmental samples were taken from utensils. Utensil samples were taken using swabs from plates before serving the relish, nsima and porridge at lunch, at dinner and at breakfast the following morning. Spoons which were used by the child when eating porridge were also swabbed.

Food samples of approximately 200 g were taken using the household utensil that was used for serving or feeding the child porridge. The samples were placed in a sterile bag with a tight-fitting seal and stored in a cold box at a temperature of 4 °C. The samples were transported approximately 80 km from Chikwawa District to a microbiology laboratory at the College of Medicine (Blantyre) within 5 h of sampling. Each sample collected was accompanied with details of the time, location and type of sample, whether it was fresh or stored food, whether the food was covered or not, and the temperature of the food at the time of sampling. Digital thermometers were used to measure the food temperature at four points: immediately after cooking, after serving in the utensil, after storage (4–6 h at room temperature), and immediately after reheating. The number of diarrhoea episodes per household for the preceding 2 weeks, together with the presence of flies or animals, and hygiene practices (e.g., handwashing at critical times and washing of utensils) were recorded.

All swab samples from the utensils were taken with sterile cotton swabs, stored in a peptone-buffered solution, and then transported to the laboratory. A 10-fold dilution was made, and 1 mL of the dilution was then transferred onto three different 3M^{TM} Petrifilm^{TM} plates: 3M^{TM} Petrifilm^{TM} *E. coli*/Coliform Count Plate, which was specific for *E. coli*, one specific for *Salmonella* sp. and one specific for *Staphylococcus aureus*. The 3M^{TM} Petrifilm^{TM} Count Plates are a sample-ready, culture-medium system that contains Violet Red Bile (VRB) nutrients, a cold-water-soluble gelling agent, an indicator of glucuronidase activity (BCIG), and a tetrazolium indicator that facilitates colony enumeration. The 3M^{TM} Petrifilms^{TM} were then incubated at 37 °C for 24 h. The 3M^{TM} Petrifilm^{TM} (3M Sciences SA, Rivonia, Johannesburg, South Africa) was used to identify and count bacterial colonies using an indicator dye and a built-in grid. Presumptive *E. coli* colonies (blue colonies with associated gas bubbles) were cultured in tryptone water at 44 °C for 24 h and an Indole test was performed with Kovac's reagent. *Staphylococcus aureus* colonies were confirmed by observing yellow coloration on mannitol salt agar after incubation for 24 h at 37 °C. *Salmonella* sp. was confirmed by growing colonies on XLD agar, and the resulting positive colonies were subcultured onto nutrient agar. For serological confirmation and serotyping of Salmonella, API^{R} 20E (BioMérieux® SA, Johannesburg, South Africa) biochemical and serology tests were done with Poly O and Poly H antisera. Thick food solids (100 g each) were homogenized with 90 mL of sterile buffered peptone water and homogenized in a stomacher blender. A 10-fold dilution was made and processed as described above.

2.6. Data Analysis

Field notes from in-depth interviews conducted after observations were analysed to identify themes for each target behaviour. These were in line with study themes such as complementary feeding practices, and the willingness to change food hygiene related behaviours. Checklist and structured observation data were reviewed and summarised to identify food contamination pathways during food storage, preparation, child feeding, reheating, and handwashing with soap at critical times.

Quantitative household data collected through Open Data Kit software (ODK) were exported to Microsoft Excel and quality checked before being exported to SPSS (version 25), where demographics, socio-economic measures, child health status and hygiene proxy measures were summarised.

2.7. Identification of Critical Control Points

The study used a HACCP approach to identify the critical control points (CCP) based on observed practices for foods consumed by under five children. This structured approach used the data from the study area to consider microbiological hazards from raw food storage to consumption [47].

2.8. Ethics

Ethical approval for this study was received from the College of Medicine Research Ethics Committee (P.04/16/1935). The study was registered with the Pan African Clinical Trials Registry (PACTR201703002084166). Written, informed consent and assent was obtained from all caregivers of children participating in the study.

3. Results

3.1. Demographic Characteristics

Of the 323 respondents (primary caregiver of the target child), the majority (66%) were in the age range of 18–28 years (Table 2). The age range of targeted children was 6–24 months (mean 14.27 with SD 5.72), of which 51% were male. A majority (90%) of families were living below the extreme poverty line (less than USD 1.25 per day), which was reflected in the levels of education, occupations and standard of housing, as summarized in Table 2. No participating households were connected to an electrical power supply and none owned a refrigerator. Of the sampled population, 95% had a latrine, which was unsurprising as the area was declared Open Defaecation Free by the Ministry of Health in 2016. Nevertheless, the majority (65%) of latrines were unimproved, and only half of them had a drop-hole cover. Despite this, only 4% of latrines had observable faeces around the drop hole. A specific place for handwashing, mostly being tippy taps (37%) was found in 51% of households. However, only 19% of handwashing facilities had soap and water. We found that the majority (64%) of handwashing facilities were located near the latrine; again, indicative of the recent Community-Led Total Sanitation campaign in the area. However, more traditional handwashing facilities such as basins and jugs were available in the household yard, and were observed to be more accessible for handwashing during food preparation and before eating (Table 2).

Table 2. Summary of demographic and hygiene facilities of sample population.

	Percentage (%)		Percentage (%)
Respondent age (years) (n = 323)		Child age (months) (n = 323)	
• 18–28	66%	• 3–6	5%
• 29–39	28%	• 7–12	39%
• 40–53	6%	• 13–18	33%
		• 19–24	23%
Occupation of respondent (n = 323)		Respondent education (n = 323)	
• Employed	2%	• Never attended school	16%
• Farmer (subsistence)	67%	• Primary level	71%
• Housewife	31%	• Secondary level	12%
		• Tertiary	1%
Marital status (n = 323)		Household basic assets (n = 323)	
• Married	87%	• Roofing with Thatch	61%
• Single	5%	• Earth Floor	89%
• Divorced	6%	• Own livestock	65%
• Widow/widower	2%	• Own radio	40%
		• Own fridge	1%
		• Own table and chair	12%
Household Monthly income (n = 323) (1USD = 750 MWK)		Animal ownership (n = 209)	
• 0–10,000 MWK	74%	• Cows	22%
• 10,000–20,000 MWK	16%	• Goats	51%
• 20,000–30,000 MWK	4%	• Sheep	2%
• 30,000–50,000 MWK	5%	• Chickens	82%
• Above 50,000 MWK	1%	• Pigs	10%
Presence of latrines (n =3 07)		Latrine cleanliness (n = 307)	
• Households with latrines	95%	• No visible dirt or faeces	43%
• Households without latrines	5%	• Dirt but no visible faeces	53%
		• Visible dirt and faeces	4%

Table 2. *Cont.*

	Percentage (%)		Percentage (%)
Presence of latrines (n =3 07)		Latrine cleanliness (n = 307)	
• Households with latrines	95%	• No visible dirt or faeces	43%
• Households without latrines	5%	• Dirt but no visible faeces	53%
		• Visible dirt and faeces	4%
Presence of drop hole covers in latrines (n = 307)		Type of latrine (n = 307)	
• Latrines with drop hole covers	50%	• Unimproved traditional	65%
• Latrines without drop hole covers	50%	• Improved traditional	35%
Presence of handwashing facilities (n=323)		Access to safe water (n = 323)	
• Households with handwashing facilities	51%	• Borehole	93%
• Households without handwashing facilities	49%	• Open well	4%
		• Household tap	2%
		• Communal tap	1%
Handwashing facility type (n = 165)		Location of handwashing facility (n = 165)	
• Tippy tap	37%	• Near latrine	64%
• Cup/basin	27%	• Near cooking area	7%
• Bucket	24%	• In HH yard	30%
• Jerry can	12%		
Household with visible flies (n = 323)	51%	Animal faeces in household yard (n = 323)	53%

Animal ownership in the area was high (65%), with the majority of these being small domesticated animals such as chickens and goats who resided both inside and outside the house. As such, animal faeces was evident in 53% of the household yards. We found that 64% of the households kept their domestic animals inside the house at night for security and the houses had no separate room for keeping animals.

3.2. Food and Hygiene Proxies

We collected both self-reported and observed data on the children's food and feeding practices (Table 3). Children were likely to start solid foods under the recommended age of 6 months (40%), although the majority were still breastfed, regardless of their age (87%). Children were given a range of foods to eat, with the majority receiving maize-based porridge (94%), and over half eating the same foods as the rest of the family at lunch and supper, which was comprised of nsima and relish (e.g., beans, vegetables). Children primarily ate at home but ate with others such as neighbours or relatives (89%). In all locations, children ate either on the veranda or ground outside the house in direct contact with dirt (42%) or placed on a reed mat (58%). Utensils for cooking and eating were reported to be washed more often after use, rather than before use; some utensils had gathered visible dust because of prolonged storage after washing. Only 6% of the utensils were found to be washed within 2 h before use.

Table 3. Self-reported and observed hygiene proxies.

Item	Percentage (%)	Item	Percentage (%)
Self-Reported Proxies			
When did the child first consume solid foods (n = 323)		What foods does the child eat (n = 323)	
• 0–3 months	0%	• Fruits	71%
• 3–6 months	40%	• Vegetables	79%
• >6 months	60%	• Milk	56%
		• Porridge	94%
		• Groundnuts	63%
		• Rice	64%
		• Beans	77%
		• Eggs	68%
		• Breastmilk	87%
		• Same food as rest of family	57%
		• Snacks	11%

Table 3. *Cont.*

Item	Percentage (%)	Item	Percentage (%)
Self-Reported Proxies			
Does the child eat anywhere apart from at home (n = 323)		Where is the child fed (n = 323)	
• Relative's house	66%	• Kitchen	2%
• Neighbour	54%	• Veranda	45%
• Nowhere	11%	• Outside house	45%
		• Inside house	8%
How long after food is prepared do you feed the child (n = 323)		Do you do anything to prevent your child from placing dirty items in their mouth (n = 323)	
• <10 min	78%	• Monitor	72%
• 10–30 min	16%	• Maintain clean environment	22%
• 30–60 min	6%	• Nothing	7%
When are utensils washed (n = 323)		Materials for washing utensils (n = 323)	
• 1–2 h before eating	1%	• Water	3%
• <1 h before eating	5%	• Water and soap	75%
• <1 h after eating	45%	• Water and ash	4%
• 1–2 h after eating	21%	• Water and flour	17%
• >2 h after eating	28%	• Sand	1%
Leftover food storage time (n = 130)			
• <1 h	34%		
• 1–6 h	62%		
• 6–24 h	3%		
• >24 h	1%		
Observed proxies (N = 80)			
Clean utensils on an elevated place	31%	Utensils washed with soap	28%
Household yards with animal faeces	66%	Households with leftover food	55%
		Type of leftover food (n = 130)	
Child observed eating porridge or snack while hands visibly dirty	39%	• Nsima	18%
		• Porridge	11%
		• Relish	43%
Households observed with children feeding themselves	40%	Households with animals accessing cooked food	20%
Households with flies around	19%	Households with animals accessing water for washing utensils/drinking	30%
Households reheating leftover food	45%	Households with drinking water covered	90%

3.3. Observational Results

Supplementary to the self-reported and observed information during the survey, the checklist and structured observations provided more detailed insight to the hygiene practices around under-two caregiving. As shown in Table 4, caregivers did not wash their hands with soap at all of the opportunities observed before food preparation, after attending to animal faeces and before eating which included child feeding. From the in-depth interviews, it was learned that caregivers did not wash hands before food preparation because of lack of proper handwashing facilities nearby. One caregiver commented: "It's very difficult to wash hands when preparing food because there is no handwashing facility nearby that can allow me to do so without assistance. Mostly if I am to wash hands then I use a cup, but I always need someone to pour water over my hands to wash properly. Unfortunately, in most cases I am only with the child."

A lack of handwashing with soap during food preparation and eating/child feeding is related to the fact that there is rarely a specific place for handwashing in the household yard, and that a majority of the handwashing facilities are located close to the latrine (64%). Facilities for handwashing in the household yard, where most activities related to hygiene take place, were buckets without a tap, which made self-handwashing difficult. When asked why they did not use the tippy tap located near the latrine as an alternative, respondents stated that the tippy tap was too far and also it would be disgusting for them to use a handwashing facility near the latrine while preparing food or before eating. 61% of the households had soap, but only 19% placed the soap at the handwashing station. During IDIs with the caregivers, they reported that soap was expensive ($0.20 per bar); hence, it is prioritized for washing clothes and bathing.

Table 4. Missed opportunities for effective handwashing (HW) at critical times during checklist observations ($n = 31$).

Observed Opportunities for HW at Critical Times	Opportunities (Number)	HW with Water Only (%)	HW with Soap (%)	No Handwashing (%)
Food preparation	73	41	0	59
Removal or contact with animal faeces	2	50	0	50
Before eating at any time	54	48	0	52
After dealing with child defaecation/urination	37	27	5	68

Results noted during checklist observations were similarly observed during structured observations, where the majority of caregivers did not wash hands with soap at critical times (Table 5). Nevertheless, all adults practised what they called handwashing before eating main meals. However, none of the adults washed their hands with soap, and 63% of them dipped their hands in one communal bowl or pot of water for a few seconds as a means of washing. During an in-depth interview, one caregiver commented that: "Eating nsima without handwashing is something we consider abnormal in this village … and I do not feel comfortable eating nsima without washing hands because it sticks in the hands … and everyone washes hands in our family before eating nsima."

Table 5. Observed handwashing (HW) practice during structured observations ($n = 80$).

Observed Opportunities for HW at Critical Times	No HW (%)	HW with Water Only (%)	HW with Soap (%)
Before child feeds itself	39%	61%	0%
Before child feeding	36%	61%	3%
Before food preparation	80%	16%	4%
Before eating (adult)	0%	100% *	0%
After dealing with child defecation/urination ($n = 17$)	70%	18%	12%

* 63% washed by dipping hands in a communal bowl or pot.

Children were also seen mouthing a variety of objects during the observation periods (Table 6). These items included hands (their own, siblings' and mothers'), inanimate objects such as cloth, maize cobs, shoes, stones, sticks, phones, utensils, paper, animal faeces and toys. They were also seen eating soil directly. Although over 90% of caregivers indicated that they monitor and prevent their children from mouthing dirty objects, we observed that the caregivers could not monitor children all the time, as they were sometimes busy with other household chores (e.g., cooking and collecting water).

Children were observed to eat the reported range of foods, with the main meals consisting of porridge, relish and nsima, with snacks including local fruits (e.g., cucumbers, mangoes, etc.) and commercial foods (e.g., maize puffs). Like adults, children washed their hands before taking their main meals by dipping their hands in one communal bowl. However, we did not observe any hand-washing before eating snacks. Forty-two percent of children were observed to self-feed, 30% were fed with a spoon by the caregiver (who, in 48% of cases, shared the utensil) and 25% were fed using the caregiver's hand. When children self-fed with a spoon, it was observed to fall on the ground, and continued to be used without any washing.

Table 6. Observed mouthing activities of children over 12 h period (n = 31).

Mouthing	Number of Observed Occurrences					
	One	Two	Three	Four	Five or More	Average Time of Episode
Childs own hands	52	23	19	16	0	3.8 min
Relatives hands	35	6	3	0	0	4.7 min
Inanimate object	13	16	16	13	29	5.6 min
Direct dirt/soil	22	-	-	-	-	5.1 min

During food preparation, opportunities for cross contamination were noted, including the lack of handwashing, and multi-tasking during cooking. For example, caregivers were seen to change a child's nappy or remove mucous from the child's nose while cooking, then resume food preparation without washing their hands. Once the food was prepared, 48% of households covered cooked foods prior to consumption. However, 19% of households were seen to leave a child's porridge uncovered to allow it to cool before consumption, leaving it open to flies and animals in the vicinity.

Up to 55% of households were observed to keep leftover food stored for the next meal which could be between 1 and 18 h later. Leftovers were primarily the children's porridge (11%), which was consumed shortly after preparation as it was left either to cool, or until the child was awake or not fussing; relish (43%), which was made of a combination of either green leaves, tomatoes, onions, or beans; and nsima (18%), which was eaten at the next meal. Bean-based relish was the most commonly stored food due to its long cooking time (about 3 h). Thus, caregivers preferred to cook relish once while nsima, which is quicker to cook (40 min), was prepared twice a day. Forty-five percent of households were observed to reheat leftover food, predominantly relish, as it was reported that reheated food tastes better than cold food. One caregiver commented during an IDI that: "We are always busy, so it is difficult and tiresome to cook the same type of relish more than once in a day … we just cook once to be enough for lunch and dinner and sometimes for breakfast for children on the following day especially if we would go to the agriculture field … also, firewood is very scarce here; hence, cooking at once saves firewood."

Twenty-one percent of children defaecated during observations. Defaecation always took place in the household yard; all of the faeces was removed from the immediate vicinity, and 76% was disposed of in the toilet. The remainder was thrown into the bushes around the household. Animal faeces was observed in 66% of the household yards. From in-depth interviews, we noted that the caregivers did not pay much attention to animal faeces, as they considered it less harmful than human faeces. One caregiver reported: "We do not bother removing animal faeces as it is not very dangerous compared to human faeces … in fact, it is a good source of manure; hence, we just throw it in the garden when sweeping the household yard in the morning."

3.4. Microbiological Results

As shown in Table 7, 224 microbiological samples were collected from 20 households, sampled at 3 different points; breakfast (n = 116), lunch (n = 38) and dinner (n = 70). We found that 30% of children within the sampled households had suffered from diarrhoea in the 2 weeks preceding, which was consistent with responses from the household survey (27%). The lack of a drop hole cover on latrines (50%), and the presence of animal faeces around the eating area (49%), in combination with the flies observed during food preparation and consumption (51%), raised concerns regarding their potential role in faecal-oral pathogen transmission in the area.

Table 7. Summary of samples taken at each stage of microbiological testing and presence of flies and animals at the time of sampling.

Meal	Food	Stage at Which Sample was Taken																Total Samples
		Freshly prepared				Stored				Reheated				Served				
		No. of Samples	Average Temp (°C)	Flies	Animals	No. of Samples	Average Temp (°C)	Flies	Animals	No. of Samples	Average Temp (°C)	Flies	Animals	No. of Samples	Average Temp (°C)	Flies	Animals	
Breakfast	Porridge	18	61	9	14	-	-	-	-	-	-	-	-	20	42	11	16	38
	Relish	-	-	-	-	20	30	12	13	19	59	11	12	-	-	-	-	39
	Nsima	-	-	-	-	19	24	10	14	20	53	13	14	-	-	-	-	39
Lunch	Relish	21	58	11	13	-	-	-	-	-	-	-	-	17	44	8	12	38
Supper	Relish	-	-	-	-	18	33	3	12	16	55	2	13	17	41	2	8	51
	Nsima	19	52	4	9	-	-	-	-	-	-	-	-	-	-	-	-	19
															Total			224

Generally, porridge was produced for immediate consumption, with leftovers being kept on only 3 occasions in the sampled households, which aligns with reported practice in the survey. All leftovers were stored in the pot in which the porridge had been cooked and left on the ground with a plate to cover it. Relish was produced predominantly for lunch (100%) and was then used again for the evening meal or breakfast (73%), meaning that these foods had the longest storage time at ambient temperature. Of all relish stored, 96% was stored in a pot or plate, of which 89% was covered. Seventy-six percent of stored food was reheated to an average temperature of 53 °C. Nsima was cooked fresh twice a day: at lunch and again for supper. Leftover nsima was stored overnight in pots and plates, with 92% being covered with a plate and 84% being placed on the ground. Eighty-seven percent of households reheated nsima for consumption at breakfast to an average temperature of 52 °C. No foods were visibly spoiled at the time of sampling.

Both total coliforms and faecal coliforms showed a significant increase in food stored for over 2 h (Figure 2). This was particularly evident in the storage of relish, which was produced at lunch on Day 1 and consumed in the morning of Day 2 as part of breakfast, with an average storage time of 18 h.

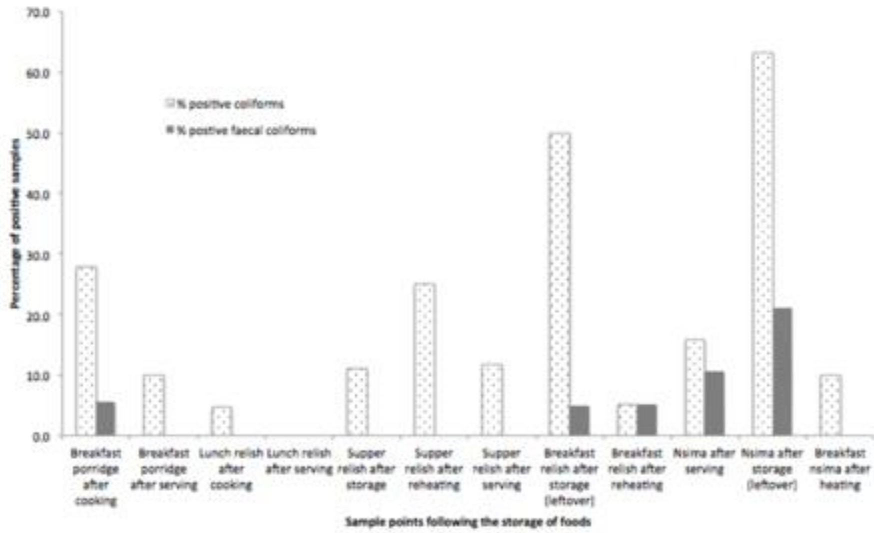

Figure 2. Percentage of food samples containing total and faecal coliforms.

Relish is reheated twice in a typical day: once for dinner, and once again for breakfast the next morning. However, an increase in the concentration of total and faecal coliforms was observed as the relish storage duration was prolonged (Figure 3a). Though the temperature does not strongly predict the presence or concentration of total coliforms, faecal coliforms appear in nsima that has been stored through the night, and the concentration is reduced by an increased serving temperature (Figure 3b). It is important to note that although reheating took place in practice, food was only reheated to the recommended 70 °C on 7 occasions (6%). We did not measure the period of time over which the temperatures were achieved, and as such, the reheating process should be examined in more detail to determine if an effective time and temperature combination can be reached taking into consideration barriers to this practice including time and cost. Of particular concern was the identification of *Staphylococcus aureus* in stored food samples. These results are indicative of poor hygiene practice related to household handwashing, and of concern in stored foods due to their production of heat stable toxins which are not destroyed by normal cooking (reheating) temperatures.

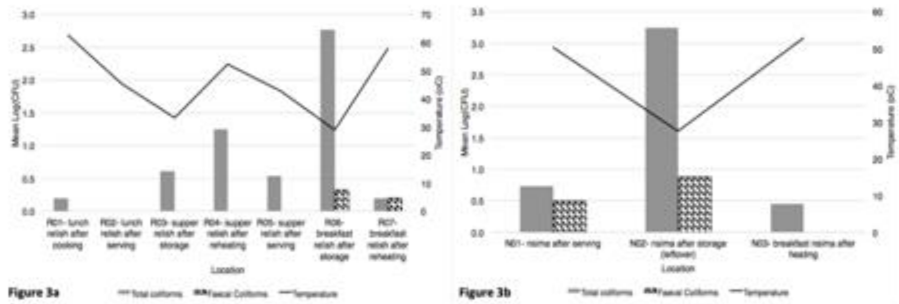

Figure 3. (**a**) Total and faecal coliform colony forming unit (CFU) changes in freshly prepared, stored and reheated relish; (**b**) Total and faecal coliform (CFU) changes in freshly prepared, stored and reheated nsima.

Freshly prepared nsima contained both total and faecal coliforms, and when the temperature dropped down to ambient temperature during storage, there was an increase in total coliforms and faecal coliforms (Figure 3b). When the nsima was subsequently reheated up to over 50 °C, all faecal coliforms were killed, but some coliforms remained, essentially unchanged from the initial product. Nsima is solid when cold, and reheating it to a consistent temperature throughout can be difficult and time consuming. Faecal contamination in this case is likely to be caused by poor handling of utensils and poor hand hygiene. As storage containers were reported to be covered, contamination was likely to be on the surface of the food, and therefore more easily destroyed during reheating.

In all cases, the cleanliness of the utensils and containers was an important variable. Although the majority of caregivers (75%) reported that they used soap when washing utensils, less than a third (29%) were observed using the soap. Alternatively, caregivers were observed to use sand/soil (53%), which could be contaminated with animal faeces. In addition, utensils were left on the ground and in areas where animals could access them. In some households (46%), animals were observed licking dirty utensils placed in a bucket or drinking water meant for cleaning. Microbiology results (Table 8) showed coliform contamination but an absence of faecal organisms.

Table 8. Summary of total coliform and faecal coliform values for each of the food (porridge, relish, nsima) and surface samples taken.

Description		Total Coliforms (CFU) *					Faecal Coliforms (CFU) **				
		No. of positive Counts	Min	Max	Mean	Median	No. of Positive Counts	Min	Max	Mean	Median
Breakfast	Mothers' hands	4	0	37,800,000	1,902,600	0	2	0	36,000,000	18,12000	0
	breakfast porridge after cooking	5	0	80,000	10,000	0	1	0	40,000	2000	0
	breakfast porridge after serving	2	0	30,000	2000	0	0	0	0	0	0
	spoon swab before feeding	2	0	200,000	12,778	0	0	0	0	0	0
	plate swab before porridge	3	0	1,820,000	115,625	0	0	0	0	0	0
	breakfast relish after storage (leftover)	10	0	76,720,000	4,663,000	5000	1	0	2,900,000	145,000	0
	breakfast relish after reheating	1	0	10,000	500	0	1	0	10,000	500	0
	nsima after storage (leftover)	12	0	10,830,000	732,600	76000	4	0	60,000	6000	0
	breakfast nsima after heating	2	0	50,000	3500	0	0	0	0	0	0
Lunch	lunch relish after cooking	1	0	10,000	500	0	0	0	0	0	0
	lunch relish after serving	0	0	0	0	0	0	0	0	0	0
	Plate swab before lunch	2	0	50,000	3000	0	0	0	0	0	0
	nsima after serving	3	0	140,000	13,000	0	2	0	140,000	10,000	0
Supper	plate swab before supper nsima	2	0	210,0000	114,737	0	0	0	0	0	0
	plate swab before supper relish	3	0	432,20000	2,168,500	0	0	0	0	0	0
	supper relish after storage	2	0	484,0000	260,000	0	0	0	0	0	0
	supper relish after reheating	4	0	948,0000	678,000	0	0	0	0	0	0
	supper relish after serving	2	0	220,0000	111,500	0	0	0	0	0	0

* Total coliforms included unidentified coliforms, E. coli, Staphylococcus aureus, Staphylococcus. Sp., Klebsiella pneumoniae, *E. coli* O157, * Enterobacter aerogenes, Enterobacter cloacae, Enterobacter sakazaki, Pseudomonas flourescence, and Seratia liquefaciens. ** Faecal coliforms included only E. coli, E. coli 0157, Enterobacter aerogenes, Enterobacter cloacae, and Enterobacter sakazaki.

3.5. Hazard Analysis

Based on the results of the qualitative and quantitative data analysis, the preparation of porridge (complementary food) and other family meals (nsima and relish) were visualized as process flow diagrams and subject to a risk assessment based on the Hazard Analysis Critical Control Point (HACCP) approach. The resultant flow diagrams (Figure 4a,b) summarize the methods of preparation while highlighting the key risks to contamination and the associated critical control points. Both figures describe the risk factors and critical control points for porridge as well as relish and nsima.

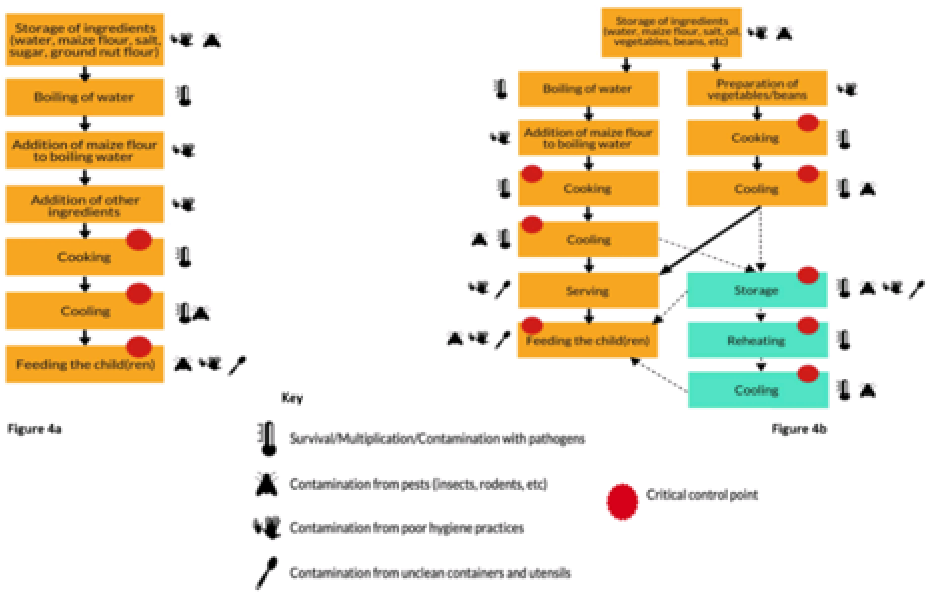

Figure 4. (**a**) Flow diagram of porridge preparation and consumption; (**b**) Flow diagram of nsima and relish preparation, storage and consumption.

Referring to Figure 4a, the CCPs for the main complementary food (porridge) were cooking, implying that the cooking temperature should be adequate (i.e., 75 °C+); cooling should be achieved quickly and food should not be accessed by animals or flies. Children should be fed with clean utensils after the caregiver has washed her/his hands with soap. CCPs for nsima and relish (Figure 4b) were similar to porridge (i.e., cooking, cooling, and feeding the child). Furthermore, since the nsima and relish are stored to be eaten during the next meal, the additional CCPs included safe storage of food (controlled storage time and temperature; food must be covered) and reheating (up to boiling) before consumption. All datasets are available as Supplementary Materials-link.

4. Discussion

Our results show that 27% of the children had suffered from diarrhoea two weeks prior to the study, which was 5% higher than the national childhood diarrhoea prevalence reported by the Malawian Demographics and Health survey [2]. Such an increased rate of diarrhoea, compounded by low levels of subsistence living requires further attention and prevention strategies in this rural setting of Malawi.

4.1. Household Meals and Contamination

Observations of complementary and family meals showed a relatively homogenous diet across the studied population. Foods were simple in nature and preparation, and in the case of children's porridge, had low levels of contamination due to the short storage/cooling times and immediate consumption. As such, the critical control points relate to the potential post-cooking contamination sources such as hands, utensils and flies/animals. Family meals of nsima and relish were more complex and leftovers were frequently stored for consumption later the same day or the next morning. As such, preventing food contamination before and during storage, along with controlling the temperature of leftover food, are critical to ensure that pathogens cannot multiply and/or are killed prior to consumption. In the absence of a cold chain in this setting, it is therefore imperative that leftover foods be a focus of food safety interventions that support high hygiene standards commensurate with the environment, such as storing food in clean and sealable containers for limited time periods.

Although the measured levels of porridge contamination were lower than those reported in Nepal, comparably low levels of contamination in complementary foods were reported in a similar rural area of Zimbabwe, where mothers were also the primary caregivers. The similarities may indicate normative regional practices in child feeding [14,40]. Despite the fact that the complementary food is safe for consumption, the method and environment in which children were being fed were risky. For instance, the practice of placing children directly on the ground during feeding increased the risk of contamination. In similar settings in Zimbabwe and Tanzania, soil analysis found *E. coli* to be ubiquitous around the household yard which could be inadvertently consumed by children during feeding, mouthing and direct consumption as we observed in this study [14,22]. Furthermore, the study in Zimbabwe estimated that a one-year old child could consume up to 4,700,000 *E. coli* counts per day, a result which could be compared to this study's setting due to the ubiquitous nature of animal and child defecation in the household yard [14].

4.2. Storage and Reheating of Food

Storing food overnight was a common practice, as caregivers were primarily subsistence farmers, and needed to save both time and fuel by preparing labour-intensive foods in the morning. Though food was adequately heated during cooking, the long storage time provided a conducive environment for microbial growth and multiplication. Reheating left-over food reduced coliforms and faecal coliforms. However, not all foods were reheated before consumption (45% reheated) (Table 3), and the temperatures reached during reheating were not always sufficient to achieve complete die-off of thermo-tolerant organisms (only 6% of samples reached the recommended 70 °C). Inadequate food reheating could be attributed to the fact that the caregivers reheated the food with the motive of improving taste rather than to kill pathogens. A study conducted in Mali in which foods were reheated to temperature in excess of 90 °C showed full die-off of thermo-tolerant bacteria [38]. This may be a reflection of the type of food being heated by households in Malawi, as the Mali study had a thinner porridge and fish soup for reheating, and is also indicative of the need to understand the context in which the food is being prepared and reheated. Ninety-four percent of participants live below the extreme poverty line, and as such, they struggle to access firewood for reheating, and even if they can, have little time to reheat food thoroughly before consumption when there are competing tasks such as collecting water, attending to children and agriculture fieldwork. As the majority of family foods are cooked to a high temperature for long periods, contamination is minimal after preparation. Therefore, focus should be on minimizing post-cooking contamination and safe storage.

4.3. Handwashing Practice

Handwashing after faecal contact, before food preparation, and before child feeding/eating snacks was rare, but comparable to previous studies [32], universal handwashing only occurred when the whole family was eating lunch or supper. This practice is therefore instilled as a social norm, with no need for prompts to make it happen. Nevertheless, the quality of handwashing before eating and at other critical times was ineffective in most cases, with little to no use of soap and use of communal water for dipping hands thereby leading to further contamination. Leftover food from communal eating is therefore subject to not only faecal-oral contamination, but also Staphylococcal pathogens such as *Staphylococcus aureus*, which, given the opportunity to multiply at the storage temperatures recorded, will produce heat-stable toxins that will survive the reheating process and cause vomiting and diarrhoea.

As with the storage and reheating of food, we must be cognizant of the context in which respondents are washing their hands and the behavioural and structural barriers which may be influencing these practices. As such, handwashing promotion needs to address the appropriate location of handwashing facilities, issues of soap use, which, due to poverty, is prioritized for other domestic activities such as bathing and washing clothes. Elsewhere, we reported that caregivers do not see the benefit in using soap for handwashing as they see no direct link between use of soap and a reduction of diarrhoeal disease in children [46]. As such, promoting handwashing with soap at critical times needs not only the provision of infrastructure, but also the development of effective behaviour-centred health promotion strategies.

4.4. Management of Household Utensils

Although this study did not show utensils to be contaminated with faecal pathogens, we observed that utensils (both clean and dirty) were left on the ground or in the open for long periods of time over which they could become contaminated with dust, faeces or from roaming animals. Previous research has reported the contamination of plastic plates and cups in Tanzania, and found high levels of faecal organisms in kitchen settings similar to those observed in this study [22]. As such, the role of utensils and the environment in which they are stored and used should be considered as a potential route of transmission for faecal-oral infections, we would recommend that items be washed just prior to use to minimise the risk of cross contamination. In addition, utensils should be rinsed with soap and water if sand was initially used to remove heavy stains.

4.5. Limitations and Further Research

This study has several limitations. Collection of study samples was conducted in October 2017 during the hot, dry season in Chikwawa, which has an average temperature of 29 °C [48]. As such, contamination levels of food and hands may be higher than would be expected in the cooler season since high temperatures favour microbial growth and survival. Further studies assessing the microbiological quality of complementary foods in both summer and winter seasons are necessary. Observations at each household were conducted by a single research assistant which increased the burden of recording events to one person and may have led to a lack of detail in some reports where concurrent activities occurred. However, as complementary food hygiene is continuously being promoted, research findings such as ours may provide guidance to public health programme designers to develop effective food hygiene promotion strategies. Although undertaken within a larger research study, of which this study is a component, water quality in households was not tested within this formative population. The study would have benefited from microbiological sampling of household members' hands after washing prior to the main meal to determine the efficacy of their practice. Hence, microbiological examination of the household water for drinking, cleaning utensils and handwashing would be an important component of future research.

5. Conclusions

This study examines the risk factors for faecal-oral routes of infection for children under the age of two years in rural Malawi. The results indicate that complementary foods produced solely for the child are relatively free from contamination, though there is a high risk associated with shared family meals, particularly those prepared from leftovers. Risks were identified from poor hand hygiene at critical times, e.g., after faecal contact, before food preparation, and before child feeding. Although handwashing before family meals was universal, the method was poor. Our findings also concur with previous studies showing that children are at risk from faecal-oral infection from their continuous contact and consumption of contaminated soil both directly and indirectly.

Interventions to reduce the risk factors should focus on the critical control points in food preparation, storage and reheating, and the contributing factors to post-cooking contamination such as hand hygiene, clean utensils and reducing contact with flies and animals. Interventions should respond to the contextual needs in which the practices occur and should be based on a behaviour-centred approach to create social norms around appropriate motives.

Supplementary Materials: The following are available online at: https://strathcloud.sharefile.eu/d-s9e3a0435c424ecb9.

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3.7 Toward complementary food hygiene practices among child caregivers in Malawi: (Paper2)

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Jurgita Slekiene: (Co - Investigator)
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Hans-Joachim Mosler: (Co - Investigator)
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Toward Complementary Food Hygiene Practices among Child Caregivers in Rural Malawi

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Abstract. Despite being preventable, foodborne diseases remain a global health challenge. Poor food hygiene practices such as improper handling of kitchen utensils are among the major causes of diarrhea transmission. A formative study was conducted in Malawi to inform an intervention design to promote complementary food hygiene practices. An assessment of contextual and psychosocial factors for behavior change was conducted using Risk, Attitude, Norms, Ability, and Self-regulation model. We conducted 323 household surveys with caregivers of children aged 6 to 24 months. Analysis of variance was used to estimate difference between doers and non-doers of three targeted behaviors: washing utensils with soap, keeping utensils on a raised place, and handwashing with soap. Analysis of variance analyses revealed that literacy level, ownership of animals, and presence of handwashing facility and dish racks were contextual factors predicting storage of utensils on an elevated place and handwashing frequencies. Psychosocial factors, such as time spent to wash utensils with soap, distance to the handwashing facility, and cost for soap, had an influence on washing utensils and handwashing practices. Perceived vulnerability determined effective handwashing and storage of utensils. Perceived social norms and ability estimates were favorable for the three targeted behaviors. Promotion of already existing targeted beneficial behaviors should be encouraged among caregivers. Risk perceptions on storage of utensils and handwashing practices should be increased with motivational exercises such as paint games. Caregivers' technical know-how of local dish rack and tippy tap construction is essential.

INTRODUCTION

Worldwide, the lives of approximately 525,000 children are lost each year from 1.7 billion cases of childhood diarrhea with the highest mortality rates reported among children aged less than 2 years in south Asia and sub-Saharan Africa.[1,2] Furthermore, it has been reported that 550 million people fall ill, whereas 230,000 die every year globally because of diarrheal diseases associated with food contamination.[3] Epidemiological data indicate that food could be more important than water in transmitting diarrheal disease,[4–6] and it is estimated that 40% of the burden of foodborne disease lies with children aged less than 5 years in low- and middle-income countries. This corresponds with reports that at least 70% of diarrhea-related pathogens among children could be caused by contaminated food.[7,8]

If children aged between 0 and 6 months are exclusively breastfed, they are expected to be free from pathogens.[7] Nevertheless, such protection is temporary because children are subsequently exposed to pathogens when introduced to complementary food between the ages of 4 and 6 months.[9,10] This exposure together with increased environmental interaction have been linked to the high incidence of diarrhea among children aged between 6 and 24 months.[2,11–13] To reduce diarrhea among children, the WHO has indicated important parameters that need to be implemented at the household level, including access to safe water, improved sanitation facilities, exclusive breast feeding, hygienic weaning practices, and improved personal and household hygiene.[14]

Food can become microbiologically contaminated if prepared under unhygienic conditions, and studies have shown that utensils, such as spoons, cups, pots, baby bottles, and plates, are potential sources of pathogens (such as *Escherichia coli*, *Salmonella*, and *Vibrio cholerae*) in food.[15,16] Contamination of utensils was attributed to the method of cleaning, resulting from repeated use of wash water and dirty cloths. Because of the risk of post-cooking contamination, the cleaning of utensils before eating, particularly for high-risk groups, is integral to food safety, as demonstrated by studies in Thailand and Mali.[17,18] As such, effective cooking of food cannot be considered as a sole critical control point, but must be combined with washing of utensils with soap and handwashing with soap at critical times.[18]

A study conducted in Bangladesh showed that caregivers have adequate knowledge of the importance of storing food and utensils on an elevated surface.[19] However, very few translate the hygiene knowledge into practice.[20] Imparting knowledge alone about food contamination pathways to caregivers has been found to be redundant and does not lead to associated changes in behavior. However, improving caregivers' perceptions while building awareness about food hygiene practices has been recommended as one of the most effective approaches to achieve positive and sustained change.[21] Contamination can also be compounded by people living in close proximity with animals. This increases the risk of food contamination if there is poor storage of utensils and leftover food, and the situation is worsened with poor handwashing practices following contact with animal and animal feces.[22,23] Previous studies conducted in Malawi showed that food is contaminated by utensils and hands during post-cooking activities.[24,25]

Recent studies have indicated the importance of handwashing in diarrheal disease reduction, with systematic reviews showing that handwashing with soap alone can reduce diarrhea incidence by 30–47%.[26,27] In Brazil and Bangladesh, studies have shown that poor hand hygiene practices during food preparation were a source of food contamination.[28,29] Because handwashing has proven to effectively contribute to enteric pathogen reduction, it is important to understand the

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psychosocial factors that drive handwashing practices and the context in which they occur.

Changing an individual's behavior is a process that requires change in contextual and psychosocial factors that predict human behavior in a given setting, such as attitudes, norms, and self-regulation attributes.[30] Based on our literature review, no detailed assessment of contextual and psychosocial factors for food hygiene practices has been conducted to identify critical factors to be addressed by a behavior change intervention for the targeted area of this formative study. Psychosocial factors have been defined as the influence of social factors on an individual's mind or behavior, and the interrelation of behavioral and social factors.[31] Contextual factors refer to the environment in which the behavior occurs, and they include the personal (e.g., age and literacy), social (e.g., economic conditions), and physical parameters (e.g., presence of sanitation facilities such as handwashing facility).[32]

The Risk, Attitude, Norms, Ability, and Self-regulation (RANAS) model[33] which was developed based on psychological theories[34,35] and has been applied in this formative study was designed to understand contextual and psychosocial parameters of individuals associated with their water, sanitation, and hygiene (WASH) practices. The model presents five "factor blocks" that should be applied to understand psychosocial factors of a study population to determine a specific behavior.

Risk factors. The risk factors respond to the level of understanding and awareness of the person's vulnerability and severity of diseases. They also include health knowledge about disease transmission, prevention options, and personal consequences.

Attitude factors. Attitude factors include beliefs about the costs and benefits of a particular behavior and feelings associated with the behavior.

Normative factors. The norm factors address the perception of what behavior is performed in the society and the level of personal obligation to a specific behavior. It includes how family and community members, including leaders, approve or disapprove a particular behavior.

Ability factors. Ability factors assess an individual's capacity to perform a certain behavior, which includes its uptake, maintenance, and recovery from drawbacks.

Self-regulation. The self-regulation factors check on an individual's plan on how to sustain a specific behavior, and they include the element on how to deal with barriers to the implementation of the behavior.

To our knowledge, the RANAS model has not been previously applied in a food hygiene assessment. However, it has been successfully used to evaluate water treatment, sanitation, and handwashing behavior.[36,37] The RANAS model is applied in two stages: 1) determine the behavior factors for the individuals under study and 2) select behavior change techniques (BCTs) that should be applied to the identified gaps.[38] Consequently, this can provide scientific guidance on which strategies to follow during an intervention. Because human behavior occurs in an environmental setting where a number of factors come into play, understanding of psychosocial factors alone may not be enough to bring about behavior change. As such, this must be complemented with details of the contextual factors in which the behavior occurs.

The objective of this formative study was to describe the situation and behavior, and to determine the contextual and psychosocial factors associated with 1) washing of household utensils with soap, 2) storing of household utensils on an elevated area, and 3) washing hands with soap at critical times. This study was a component of a larger body of work to understand behavioral factors related to complementary food hygiene in the development of an intervention trial.

MATERIALS AND METHODS

Study area. The formative study was conducted in three rural administrative Traditional Authorities of Masache, Ngowe/Ngabu and Maseya in Chikwawa district in southern Malawi. During the 2018 population census, the Chikwawa district population was 564,684,[39] and Chichewa is the main language of the area. Chikwawa is in a low-lying area and, therefore, prone to flooding in the rainy season. Similar to other districts of Malawi, Chikwawa has two seasons per year, that is, rainy/farming season that lasts from November to April and dry/off farming season from May to October. The district has an annual average temperature of 25.7°C and an average rainfall of 797 mm.[40]

Three Traditional Authorities were chosen taking into account their geographic location (rural remote area), socioeconomic variability (low-income communities), and access to protected water sources and high sanitation coverage (declared open defecation free), but with a continued high risk of cholera and diarrhea. Households in the targeted villages are very close to each other, and this provides an opportunity for communities to have common values and share WASH, including food hygiene issues without social resistance.

Study population and sampling. This formative study targeted caregivers and their children aged 6 to 24 months. In this article, the word caregiver includes any household member, including parents who are responsible for daily care of the targeted child. This includes feeding and preparing the child's food, bathing, and assisting the child during defecation. With the use of information from the community health workers' (i.e., locally known as health surveillance assistants) register, a list was drawn up of households with children aged between 6 to 24 months, having a pit latrine, and with access to safe water within a distance of 500 m. A sample size of 295 was calculated based on Chikwawa district diarrhea prevalence of 26.3% with an acceptable error margin of 5%.[41] Taking into account of nonresponse rate and missing data, the sample size was increased to 323.

Data collection. The research team collected data from February to July 2017. As behaviors are determined by a wide range of factors, it was necessary to use different data collection methods to reveal the complexity of the socioeconomic, cultural, and other factors that influence the child caregiver's decision on the "what," "how," "when," and "why" of infant and child feeding practices. Therefore, formative data were collected from four complementary phases which included checklist and structured observations, in-depth interviews, household surveys (i.e., demographic and RANAS questions), and focus group discussions. This article presents only findings from household survey. All households (323) undertook the combined demographic and RANAS model–based household questionnaire. Initially, before conducting household surveys, observations were conducted which identified three critical behaviors: 1) washing utensils with soap, 2) keeping utensils on an elevated area, and 3) handwashing with soap at critical times, where critical times in this article mean handwashing with soap before food preparation; before eating, including child feeding; after changing child's nappy; and after latrine use by the caregiver.

The identified three critical behaviors noted during observations were further assessed for the contextual and psychosocial factors using the RANAS model–based household questionnaire (n = 323) which was translated into the local language of Chikwawa district (Chichewa). Responses to the RANAS questions were recorded on a 5-point Likert scale (ranging from "not at all" to "very much" scale). The household survey questionnaire was mainly composed of closed questions that captured information about demographics, child feeding, health status and awareness, psychosocial factors related to washing utensils with soap, keeping utensils on elevated area, and handwashing with soap at critical times (example item in Table 1). Furthermore, the questionnaire contained rapid spot checks related to sanitation and hygiene structures which could be objectively observed.

Household survey data collection was conducted by 10 well-trained and experienced research assistants who were fluent in the local language (Chichewa). Pretesting of the questionnaire was conducted before data collection where the research team identified and eliminated irrelevant questions, whereas key questions were further edited for easy understanding.

Data analysis. Demographic household and RANAS data were collected using Open Data Kit software (Department of Computer Science and Engineering, University of Washington, Seattle, WA) on android tablets and exported to Microsoft Excel (Microsoft corporation, Redmond, WA) and quality checked before being exported to Statistical Package for Social Sciences (SPSS) where frequency distribution of demographic characteristics using descriptive statistics was plotted. IBM SPSS version 25, the PROCESS macro for SPSS, was used to undertake all statistical tests (IBM, Armonk, NY). The household RANAS model–based data were analyzed using ANOVA mean comparison analysis to determine the differences between doer and non-doer contextual and psychosocial factors for the targeted behaviors. To measure the three targeted behaviors, data collectors asked caregivers how often they washed utensils with soap, how often they kept utensils on a raised place, and how often they washed hands with soap at critical times. Frequencies were measured on a 5-point scale. All factors falling at or below the mid 3-point value on a scale of 1–5 were considered non-doers of the targeted behaviors, whereas those factors at or above 4 were doers of the behavior, and the mean score for each targeted behavior was calculated. Washing utensils with soap, keeping utensils on an elevated area, and handwashing with soap were dependent variables, whereas behavioral factors of the RANAS model were independent variables. Three questions were asked to caregivers to assess knowledge about diarrheal disease causation, signs, and preventive measures. The ratio of correct answers from the caregivers to all possible answers formed the health knowledge constructs. A single item was used to measure perceived severity, whereas perceived vulnerability of diarrhea and other psychosocial factors were

TABLE 1

Risk, Attitude, Norms, Ability, and Self-regulation model–based questionnaire (e.g., factors and items for washing utensils with soap)

Behavior determinants	Selected items
Risk factors	
Vulnerability	In general, how high do you think is the risk that you get diarrhea?
Severity	Imagine that you contracted diarrhea. How severe would be the impact on your life in general?
Health knowledge	Can you tell me what causes diarrhea? Could you please tell me if each of the following is a cause or not? For example, no handwashing with soap after defecation. Could you please tell me for each whether it is a preventive measure for diarrhea or not? For example, drink treated water
Attitudinal factors	
Belief—effort	How pleasant is it for you to wash kitchen utensils with soap and water?
Belief—time-consuming	How time-consuming is it to wash kitchen utensils with soap and water?
Belief—expensive	How expensive is it for you to always wash kitchen utensils with soap and water?
Feelings	How much do you like always washing kitchen utensils with soap and water?
Normative factors	
Others' behavior household	How many people of your household always wash kitchen utensils with soap and water?
Others' behavior village	How many people of your village always wash kitchen utensils with soap and water?
Others' approval	People who are important to you like your family members, friends, Non Governmental Organization (NGO) workers, or pastor, how much do they approve that you always wash kitchen utensils with soap and water?
Personal obligation	How strong do you feel a personal obligation to yourself to always wash kitchen utensils with soap and water?
Ability factors	
Confidence in performance	How confident are you that you can always wash kitchen utensils with soap and water?
Difficult water	How difficult is it to always get water for washing kitchen utensils?
Barriers hurry	Imagine that you are in a hurry, for example, because you want to go for relief distribution: How confident are you that you can always wash kitchen utensils with soap and water?
Self-regulation factors	
Coping plan	Do you have a plan what to do so that you always have soap for washing kitchen utensils? Plan, please specify.
Remembering (pay attention)	How much do you pay attention to washing utensils with soap and water?
Remembering (forgetting last 24 hours)	When you think about the last 24 hours: How often did it happen that you forgot to wash kitchen utensils with soap and water?
Commitment (important)	How important is it for you to wash kitchen utensils with soap and water?
Washing utensils with soap behavior	How often do you wash kitchen utensils with soap?

Response scales: 5-point Likert scale (from "not at all" to "very much"; from "at no time" to "almost each time"; from "never" to "very often"; and from "nobody" to "almost all of them").

measured with multiple items. The WHO and United Nations Children's Fund definition of diarrhea was used when assessing diarrhea incidence among targeted children.[11] For each targeted behavior, the significant factors among those noted with ANOVA calculation were further analyzed (i.e., any factor at $P < 0.05$ using ANOVA) with effect size, d, where Cohen's d values mean small for those = or < 0.20, medium = or < 0.50, and large = or > 0.80.

Ethics. The formative study protocol was approved by the University of Malawi's College of Medicine Research Ethics Committee (P.04/16/1935). Permission was obtained from the local authorities, that is, Chikwawa district council, Chikwawa district health office, and the traditional chiefs. The participants were informed of the research objectives and were advised that they had the freedom to refuse participation or withdraw from the study at any time. Participants' written informed consent was obtained before inclusion in the study. Participants were provided with a unique identifying number, and data were anonymized during data analysis. Data were accessed only by the authors. The study was registered with the Pan African Clinical Trials Registry (PACTR201703002084166).

RESULTS

Sociodemographic characteristics. All respondents of the household questionnaire were females whose age ranged from 18 to 53 years (mean 26.72 with SD 6.78). The majority of them (71%) attended primary education, whereas 16% had never been to school. Income was primarily from subsistence farming (67%), and majority of the households (74%) earned at most $14 per month. As such, households reported some levels of uncertainty about food supply. The age range of targeted children was 6–24 months (mean 14.27 with SD 5.72) of which 49% were females. Forty percent of children were introduced to complementary food (i.e., porridge from maize flour) when they were between 3 and 6 months old, and 27% of the targeted children were reported to have had diarrhea in the 2 weeks before the survey. No participating households were connected to an electrical power supply, and therefore, none owned a refrigerator. Domesticated animals, such as pigs, dogs, goat and poultry, were observed roaming freely in household yards. Human and animal feces were observed in 2% and 52.9% of the household yards, respectively.

Caregivers accessed safe water through boreholes (93%) and piped water supply (3%). Latrines were owned by 95% of the households, whereas 5% either depended on their neighbors' latrine or practiced open defecation. Despite high coverage, most toilets were unimproved traditional latrines (64%) subject to collapse during the rainy season and offering minimal privacy. Soap was available in 61% of the households, and it was prioritized in the following order: washing clothes, bathing, washing kitchen utensils, and handwashing.

Contextual factors: doer versus non-doer analysis. Contextual factors were compared between doers and non-doers of the three targeted behaviors. Statistical analysis identified significant variables related to handwashing with soap and keeping of utensils on an elevated place, whereas no significant variables were observed for washing utensils with soap (Table 2). Factors that were found to be significant for handwashing included level of literacy, where those who were literate washed hands with soap at critical times more frequently than those who were not literate (doers = 50%; non-doers = 38%). Similarly, caregivers who had handwashing facilities reported to wash hands with soap more than those who had no handwashing facilities (doers = 59%; non-doers = 46%). On keeping utensils, caregivers who had domestic animals kept their utensils more frequently on an elevated place than those who had no animals (doers = 78%; non-doers = 60%), and those who had locally made dish racks kept their utensils more on an elevated place than those who had no dish racks (doers = 75%; non-doers = 14%).

Psychosocial factors: washing of household utensils. From the household spot checks, the study noted that 29% of the caregivers washed their utensils with soap. Risk, Attitude, Norms, Abilities, and Self-regulation model–based questions were asked to understand psychosocial factors that contributed to caregivers not using soap when washing utensils. As shown in Table 3, we did not find significant differences between doers and non-doers on vulnerability, severity, health knowledge, attitude (effort), personal obligation, and commitment (importance). As such, these factors should not be the focus for a behavior intervention. Significant differences with medium to high cohen's d values were found on others' behavior (relatives; $d = 0.64$), others' approval ($d = 0.74$), and confidence in performance (continuation—barrier water; $d = 0.7$), where non-doers reported highly that they could not wash utensils with soap because of inadequate water at the household (Table 3). This means that these factors should be key targets for behavior change among non-doers of washing utensils with soap. Medium effect was found in the attitude factor "pleasant" ($d = 0.45$) and self-regulation (remembering;

TABLE 2

Comparison of contextual factors of the study participants on washing of utensils with soap, keeping utensils on a raised place, and handwashing with soap

Variable	Scale	Washing utensils with soap		Keeping utensils on raised a place		Handwashing with soap	
		Doer	Non-doer	Doer	Non-doer	Doer	Non-doer
Literacy	Yes/No	47%	40%	47%	42%	50%*	38%*
Marital status	Yes/No	86%	87%	84%	87%	85%	87%
Age in years *mean* (SD)	–	25.73 (6.0)	27.60 (7.3)	27.18 (6.9)	26.55 (6.8)	25.46 (6.2)	27.57 (7.0)
Owned land for farming	Yes/No	82%	84%	78%	85%	83%	84%
Owned livestock	Yes/No	69%	62%	78%*	60%*	68%	63%
Presence of bicycle	Yes/No	64%	61%	69%	60%	66%	60%
Presence of radio	Yes/No	40%	40%	44%	38%	39%	40%
Presence of handwashing facility	Yes/No	–	–	–	–	59%*	46%*
Presence of dish rack	Yes/No	–	–	75%†	14%†	–	–

* $P \le 0.05$.
† $P \le 0.001$; $N = 323$.

TABLE 3
Washing of utensils with soap: doer and non-doer Risk, Attitude, Norms, Ability, and Self-regulation psychosocial factors' mean compared with analysis of variance

Factors group	Behavioral factors	Doers, *M* (SD)	Non-doers, *M* (SD)	Cohen's *d*
Risk factors	Vulnerability	4.06 (1.39)	3.80 (1.48)	n.s.
	Severity	4.36 (0.97)	4.24 (1.06)	n.s.
	Health knowledge	9.29 (3.09)	8.83 (3.22)	n.s.
Attitude factors	Pleasant†	4.8 (0.65)	4.38 (1.15)	0.45
	Time‡	1.14 (0.41)	1.3 (0.82)	0.25
	Effort	1.13 (0.64)	1.22 (0.66)	n.s.
Norms	Others' behavior relatives†	3.26 (1.3)	2.51 (1.02)	0.64
	Others' behavior village‡	2.88 (1.01)	2.54 (0.9)	0.36
	Others' approval†	4.79 (0.51)	4.2 (1.01)	0.74
	Personal obligation	2.42 (1.86)	2.37 (1.73)	n.s.
Ability factors	Ability (confidence in performance [continuation]—barrier: water)†	4.33 (0.97)	3.57 (1.2)	0.7
Self-regulation factors	Commitment (importance)	4.88 (0.57)	4.79 (0.67)	n.s.
	Remembering (forgetting)†	2.61 (1.16)	3.12 (1.15)	0.44
Additional factors	Intention‡	3.82 (1.4)	3.34 (1.52)	0.33
	Communication‡	3.14 (1.42)	2.73 (1.32)	0.3

n.s. = not significant.
N = 323; washing of utensils with soap: doers N = 154 and non-doers N = 169. All questions (excluding knowledge questions, which were sum score) included a 5-point Likert scale and response choices from "1—not at all" to "5—very much."
† $P \leq 0.001$.
‡ $P \leq 0.01$.

d = 0.44), meaning that doers found it more pleasant to wash utensils with soap than non-doers. Similarly, the doers were less likely to forget to wash their utensils with soap than the non-doers. Slightly significant differences between doers and non-doers were noted on others' behavior (village; *d* = 0.36), intention (*d* = 0.33), and communication (*d* = 0.3). This implies that non-doers do not desire much to wash their utensils with soap than the doers. In addition, the non-doers do not discuss much with their friends or relatives about the practice of washing utensils with soap compared with the doers.

Psychosocial factors: storage of clean utensils. The study found that 31% of the caregivers kept their utensils on an elevated place that could not easily be reached by animals. On psychosocial factors related to storage of utensils on an elevated place, significant differences between doers and non-doers could not be found on severity, health knowledge, attitude (time and effort), and personal obligation (Table 4). Hence, these factors should not be prioritized for intervention. However, statistical differences on cohen's *d* values were noted on others' behavior (relatives; *d* = 0.71 and village; *d* = 0.82), others' approval (*d* = 0.6), and confidence in performance which included "difficult" (*d* = 0.44), "hurry" (*d* = 57), and "restart" (*d* = 0.65) (Table 4). This implies that non-doers perceived that people in their village, including their relatives, do not keep their utensils on an elevated place. In addition, the non-doers were unlikely to restart or continue keeping utensils on a raised place if they stopped for other reasons and found it more difficult to keep or dry their utensils on a raised place if they do not have a dish rack. The non-doers also perceived that they communicate less with others (*d* = 0.47) about using an elevated surface to keep or dry their utensils and felt less vulnerable (*d* = 0.58) to the risk of diarrheal disease than doers, which is related to the non-doers perception that keeping utensils on a raised place is not a pleasant practice (*d* = 0.35).

TABLE 4
Keeping of utensils on an elevated position: doer and non-doer Risk, Attitude, Norms, abilities, and Self-regulation psychosocial factors' mean compared with analysis of variance

Factors	Behavioral factors	Doers, *M* (SD)	Non-doers, *M* (SD)	Cohen's *d*
Risk factors	Vulnerability†	4.19 (1.27)	3.35 (1.61)	0.58
	Severity	4.37 (0.94)	4.27 (1.04)	n.s.
	Health knowledge	8.78 (2.85)	9.15 (3.27)	n.s.
Attitude factors	Pleasant‡	4.69 (0.88)	4.33 (1.23)	0.35
	Time	1.28 (0.82)	1.21 (0.7)	n.s.
	Effort	1.08 (0.49)	1.21 (0.7)	n.s.
Norm factors	Others' behavior relatives†	2.99 (1.27)	2.16 (1.06)	0.71
	Others' behavior village†	2.92 (0.99)	2.19 (0.79)	0.82
	Others' approval†	4.49 (0.8)	3.83 (1.22)	0.6
	Personal obligation	2.58 (1.92)	2.4 (1.73)	n.s.
Ability factors	Confidence in performance (difficult)†	4.25 (1.34)	3.61 (1.56)	0.44
	Confidence in performance (hurry)†	4.16 (1.42)	3.26 (1.74)	0.57
	Confidence in performance (restart)†	4.63 (0.9)	3.81 (1.54)	0.65
Self-regulation	Commitment (importance)	2.60 (1.94)	2.20 (1.73)	n.s.
	Remembering (forgetting)	1.06 (0.47)	1.19 (0.5)	n.s.
Additional factors	Communication†	3.19 (1.4)	2.53 (1.41)	0.47

n.s. = not significant.
N = 323; Keeping of utensils on a raised place: doers N = 88 and non-doers N = 235. All questions (excluding knowledge questions, which were sum score) included a 5-point Likert scale and response choices from "1—not at all" to "5—very much."
† $P \leq 0.001$.
‡ $P \leq 0.01$.

Psychosocial factors: handwashing with soap at critical times. A specific place for handwashing was found in 51% of the households, of which 62% were located near the latrine. However, only 19% of the handwashing facilities had soap and water. The study explored psychosocial factors that contributed to nonuse of soap when washing hands at critical times. As shown in Table 5, the highest associated population effect sizes for handwashing with soap at critical times were attitude (like; d = 1.17) and confidence in continuation (d = 0.81). This implies that non-doers show a lower preference to washing their hands with soap and are less likely to continue using soap when washing hands at critical times. Furthermore, the non-doers found it expensive (soap; d = 0.56) and time-consuming (time; d = 0.45) to wash hands with soap compared with the doers. The factor attitude (distance) was also found to be significant (d = 0.34). As such non-doers perceived that the handwashing facility located near the latrine was too far for them to wash hands with soap during other critical times of handwashing, such as before preparing food. The caregivers found it hard to have another handwashing facility within the cooking area because they had no technical know-how on handwashing facility construction. They depended on their husbands to construct the handwashing facilities, but they, in most cases, were reportedly engaged with food-fetching activities for the home. Other significant factors included cost (d = 0.27), others' behavior (relatives; d = 0.76 and village d = 0.54), remembering (d = 0.7), and communication (d = 0.62). Furthermore, risk factors (vulnerability and severity) were slightly significant for handwashing with soap practice (d = 0.26 and 0.28, respectively). This means that doers found it more probable that they would suffer from diarrhea and its severity would be more, compared with the non-doers, although health knowledge, time, effort, confidence in performance (water), and commitment (importance) were insignificant.

Selection of the behavior change techniques. Based on the results from formative data, the RANAS model fact sheet[33] provided guidance on which BCTs should be applied for the behavioral interventions. Evidence-based decisions in the choice of BCTs to promote complementary food hygiene practices were derived from analysis of contextual and psychosocial factors. Furthermore, household spot checks noted that only 29% and 31% of the visited households had soap for washing utensils and had an elevated place for keeping kitchen utensils, respectively, whereas handwashing facilities with soap and water were noted in 19% of the households. The formative data provided a platform for developing interventions with an overall aim of promoting child caregivers toward improved complementary food hygiene practices. As shown in Table 6, the strategies considered for the interventions would aim the following. 1) Build awareness on complementary food hygiene habits at an individual and community level. 2) Reinforce the ability to wash hands with soap at all critical times, wash utensils with soap, and keep them on an elevated place. Thus, interventions to improve infrastructure (i.e., dish racks and handwashing facilities) are being suggested to boost caregiver's self-efficacy and, therefore, increase their confidence to perform the behaviors.[42] In addition, their confidence in performance would be enhanced through demonstrations such as "Glo germ gel" and "hand and utensil painting exercise" (see the following paragraphs) that would lead to an increased perception of self-efficacy. 3) Indicate that others are already performing the desired practices. Thus, public commitment to show that others are performing the targeted behaviors would be performed through open days where caregivers would also sing songs about targeted behaviors. Public pledges would enhance normative factors and posters to be placed outside caregivers' houses would show community members that others are performing targeted behaviors that would boost descriptive norms. 4) Reinforce

TABLE 5

Handwashing at critical times: doer and non-doer Risk, Attitude, Norms, Abilities, and Self-regulation psychosocial factors' mean compared with analysis of variance

Factors	Behavioral factors	Doers, *M* (SD)	Non-doers, *M* (SD)	Cohen's *d*
Risk factors	Vulnerability*	4.36 (1)	4.08 (1.16)	0.26
	Severity*	4.46 (0.86)	4.18 (1.1)	0.28
	Health knowledge	9.4 (3.25)	8.8 (3.09)	n.s.
Attitude factors	Time	1.07 (0.47)	1.16 (0.62)	n.s.
	Effort	1.11 (0.57)	1.17 (0.72)	n.s.
	Distance†	1.41 (1.2)	1.9 (1.61)	0.34
	Cost*	1.55 (1.23)	1.92 (1.46)	0.27
	Handwashing removes germs‡	4.86 (0.51)	4.46 (1)	0.5
	Like‡	4.43 (1.03)	3.05 (1.31)	1.17
Norm factors	Others' behavior relatives‡	3.9 (1.24)	2.89 (1.47)	0.76
	Others' behavior village‡	2.9 (1)	2.37 (0.96)	0.54
	others' approval‡	4.76 (0.68)	4.43 (1.03)	0.38
Ability factors	confidence in performance (sure)‡	4.69 (0.79)	3.7 (1.54)	0.81
	confidence in performance (water)	1.11 (0.62)	1.11 (0.54)	n.s.
	confidence in performance (soap)‡	1.57 (1.19)	2.35 (1.59)	0.56
	confidence in performance (time)‡	1.05 (0.29)	1.38 (1)	0.45
Self-regulation	remembering (forgetting)‡	1.73 (1)	2.66 (1.6)	0.7
	commitment (importance)	4.86 (0.49)	4.85 (0.55)	n.s.
Additional factors	communication‡	3.39 (1.39)	2.55 (1.31)	0.62

n.s. = not significant.
N = 323; handwashing with soap at critical times: doers N = 132 and non-doers N = 191. All questions (excluding knowledge questions, which were sum score) included a 5-point Likert scale and response choices from "1—not at all" to "5—very much."
* $P \leq 0.05$.
† $P \leq 0.01$.
‡ $P \leq 0.001$.

TABLE 6
Translation into practical strategies

RANAS factor blocks	Behavior	Target RANAS behavioral determinants	Definitions of the behavioral determinants	Intervention types	Corresponding RANAS behavior change technique	Practical strategies
Risk factors	Keeping utensils on elevated area and handwashing with soap	Perceived vulnerability	Perception of the seriousness of suffering from diarrhea	Information interventions	Provide practical information on behavior and health outcomes	Create practical information exercises and posters
Norm factors	Washing utensils with soap, keeping utensils on raised place, and handwashing with soap	Descriptive and injunctive norms	Perception of other caregivers performing the three behaviors	Normative interventions	Flag out norms	Public commitment event through open days and cluster meetings. Role-model guided practice. Create posters
Ability factors	Washing utensils with soap	Action self-efficacy	Certain to always wash utensils with soap	Ability interventions	Increase confidence in behavior: prompt guided practice	Create practical exercises
	Keeping utensils on raised place	Action self-efficacy	Certain to always be able to keep utensils on a raised place	Infrastructure and ability interventions	Increase confidence in behavior: performance by providing practical instructions	Provide practical instructions on dish rack construction and show pleasantness of the behavior
	Handwashing with soap	Action self-efficacy	Certain to always be able to wash hands with soap at four critical times	Infrastructure and ability interventions	Increase confidence in behavior: performance by providing practical instructions	Create games and provide practical instructions on tippy tap construction
Self-regulation factors	Handwashing with soap	Action self-efficacy	Certain to always be able to wash hands with soap	Remembering intervention	Memory aids and environmental prompts	Create memory aids for handwashing

RANAS = Risk, Attitude, Norms, Ability, and Self-regulation.

the action self-efficacy through use of attractive posters with key messages to remind caregivers to always wash utensils and hands with soap will enhance their confidence to practice the behavior.

DISCUSSION

As reported in other developing countries, complementary food hygiene is suboptimal in Malawi,[18,21,43–45] and high prevalence of diarrhea among children in this study suggests that food hygiene practices such as these may play an important role in child health. However, motivators and barriers for food hygiene improvements in this setting were not clearly understood. For the first time, our study assessed the contextual and psychosocial factors related to caregivers' food hygiene practices in rural Malawi. Such data were necessary for the development of population-tailored behavior change interventions. In this formative study, data were collected from child caregivers who had children aged between 6 and 24 months in Chikwawa, Malawi. Normative factors about others' behavior and ability factors were identified as the main factors for all three behaviors. In addition, the self-regulation factor (remembering) was found to be a strong predictor of handwashing with soap at critical times. Guided practice, memory aids, information about others' behavior, and model behavior are being considered in a behavior change intervention for improved practices on washing of utensils with soap, keeping utensils on a raised place and handwashing with soap at critical times.

Although we acknowledged that washing utensils without soap is not the only risk factor for diarrhea among children, the practice of washing utensils without soap could increase the risk of food contamination as this is a proven route of pathogen transmission.[15,16] As such, the creation of effective promotion strategies to encourage the use of soap to wash utensils is important. The practice of placing utensils on the ground before, during, and after washing utensils is common in Malawi and may increase the risk of childhood diarrhea contaminating utensils with pathogens in soil and animals (directly and via feces). Nevertheless, this study found that the presence of a dish rack at a household influenced the doers to keep their utensils on an elevated place compared with the non-doers. Previous research has shown that promoting existing beneficial behavior is important in addressing local needs.[19] Thus, the safe practice of using locally made dish racks which is already performed by a few (31%) in the study area should be promoted.

In this study, use of soap for handwashing was uncommon. Soap was found to be prioritized for other household usage such as washing clothes and bathing. Contrary to what was reported by Seimetz et al.,[46] purchase of soap in this study was found to slightly influence handwashing with soap practice. However, usage of soap greatly depended on influence from others and the availability of a convenient place for handwashing. Failure of caregivers to wash hands because of the lack of a handwashing facility confirms what has been previously reported that a specific place for handwashing is a predictor of household handwashing frequency.[47,48] Generally, 62% of the handwashing facilities were located near the latrine (behind and away from the cooking area) which affected the frequency of caregivers' washing hands at other critical times (e.g., during food preparation). Furthermore, it has been shown in this study that the presence of a handwashing facility at a household increased the handwashing practice among the doers compared with the non-doers. Thus, constructing additional handwashing facilities within the cooking area could improve the frequency of handwashing practice.

Interpretation of results and implication for practice. Three knowledge sections in the questionnaire showed no significant difference between doers and non-doers about diarrhea causation, signs/symptoms, and prevention as knowledge was found to be high in both groups. However, significant differences in risk perception between doers and non-doers were noticed on keeping utensils on a raised place and handwashing with soap practices. Thus, practical strategies to sensitize the caregivers to the health risks associated with storage of utensils and handwashing with soap should be incorporated in an intervention.

Washing utensils with soap, keeping utensils on an elevated surface, and handwashing with soap strongly interdepended on the normative factor—others' behavior (i.e., relatives and friends). A study in Nepal showed that influence from others plays a major role in one's behavior about sanitation and hygiene.[49] Therefore, corresponding normative BCTs should be applied to facilitate behavior change. As community meetings have been reported to strengthen normative elements,[50,51] group meetings with caregivers would be essential where a positive group identity would be reinforced and role models would be identified to promote the behaviors. In addition, communication about the behaviors among caregivers would be strengthened through the group meetings. Household visits would be conducted as follow-up to group meetings to prompt guided and behavioral practice at an individual level. Importantly, BCTs related to personal commitment would be appropriate to address personal norms toward the three behaviors. Such commitment should be made in public by caregivers together with their husbands as they have been found to have a major role in the construction of handwashing facilities and dish racks. As reported in other behavior change studies,[36,37,49] public pledges would also help to reach out to more people and, thus, change descriptive norms. Having adequate water at the household increased the confidence of caregivers to wash utensils with soap. This suggests that promoting adequate water availability at households is a potential strategy for washing utensils with soap. Role models on this practice should be encouraged to demonstrate to others how they manage to have adequate water in their homes for washing utensils.

Caregivers' abilities (confidence in performance) to keep utensils on an elevated place and wash utensils and hands with soap were a very strong predictor for the practice of these behaviors. The lower perceived self-efficacy in washing utensils with soap, keeping utensils on an elevated place, and handwashing with soap among the non-doers requires the implementation of a corresponding BCT. Demonstrations such as "Glo germ gel" and "hand and utensil painting exercise" could be applied to strengthen caregiver's belief and ability to continuously use soap when washing hands and utensils as its effectiveness would be appreciated. Hand painting exercises show the potential movement of pathogens from one person to another through hand shaking and being in contact with household items, for example, utensils. Participants put paint in their palm and then shake hands among themselves and touch household items to represent spreading of germs. While having paint in the hands, some are asked to wash hands with soap, whereas others without and notice the difference. Similarly, the utensil painting exercise demonstrates the effectiveness of soap in removing dirt and germs from utensils such as plate. Handwashing Glo germ gel reveals areas in the hands that are concentrated with germs.[52] Practical demonstrations on dish rack and hand washing facility construction should be promoted to strengthen the perception of self-efficacy, thus reinforcing ability factors. In addition, the use of behavioral cues should be incorporated to remind caregivers' abilities to wash utensils and hands with soap. The use of such interesting and innovative approaches has proven to be effective in behavior change initiatives.[53–55]

LIMITATIONS OF THE STUDY

Self-reported findings are prone to bias as the participants may report what the researcher wants to hear. However, this was controlled by conducting spot checks on some of the variables that were reported by the participants. Food hygiene practices cover additional practices to those covered in this article, such as storage conditions and reheating of leftover food. However, further analysis of formative research findings assessed these parameters in the same study setting. Sociocultural practices and geographical conditions across Malawi may differ; hence, the results of this study may not be applied to all the rural areas without further study. In addition, during recruitment, all study households had a latrine and access to safe water within a distance of 300 m. This is not the case with other households in rural settings of Malawi. However, despite the stated limitations, this research provides a good platform for understanding the contextual and psychosocial factors related to complementary food hygiene practices for the design of an effective food hygiene intervention in rural Malawi.

CONCLUSION

This study for the first time has applied the RANAS model to assess contextual and psychosocial factors influencing child caregivers' behavior relating to food hygiene practices in rural Malawi. This research provides evidence-based results as a basis for the development and implementation of food hygiene interventions to contribute toward prevention of diarrheal diseases. Selected contextual (i.e., presence of handwashing facility, locally made dish rack and ownership of animals) and psychosocial factors which include normative, ability, and self-regulation (remembering) factors have been identified as strong predictors for the success of an intervention that focuses on washing of utensils with soap, keeping of utensils on an elevated place, and hand washing with soap at critical times. Therefore, they should be considered for promotion in future initiatives.

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3.8 Key findings of the formative research

This formative research provided important data and insights to inform the design of a context appropriate food hygiene intervention. It identified key food hygiene behaviours including their associated behavioural factors that may be considered in an intervention to promote food hygiene practices of child caregivers who have children under the age of five years in low- and middle-income settings.

3.8.1 Identified contextual factors

The study results (from both paper 1 and paper 2) have shown that most households in the study setting live below the World Bank's extreme poverty line of USD 1.90 a day, a situation that requires further attention and context-appropriate health promotion strategies. Literacy level was found to influence performance of some of the targeted behaviours; for instance, those who were literate washed their hands with soap at critical times more frequently than those who were not literate. At household level, the main child caregiver (mostly mother to the targeted child), was multi-tasking, hence she could not ensure that the child was protected from exposure to widespread environmental contamination at all times. While the men, despite being key decision makers in the household, were rarely involved in domestic food hygiene practices. It was evident that children primarily ate at home, where they have specific utensils allocated. However, from time to time they also ate with neighbours or relatives where practices may vary. Importantly, lack of WASH infrastructure (e.g. handwashing facility and a dish rack) was associated with poor performance of the targeted behaviours in the household. At household level, there was homogeneity in terms of food given to the children and adults. In addition, there were no specific eating place (e.g. a mat) meant for the children and all left over food was stored under the same conditions (i.e. temperature, storage utensils and place). Since the formative study was conducted during farming season, the primary child caregivers (i.e. mothers to the children) were rarely available at the household as they spent most of their day time in the agriculture fields. As such older children were left to look after their young siblings including feeding. It is important that food hygiene interventions in these settings should be designed in such a way that those who spend most of their time in the agriculture fields are also captured. For instance, if cluster meetings are to be used as a channel of communicating hygiene promotion messages, there will be a need for repetition of the health promotion modules to ensure that those who missed the previous meeting are captured. This would also improve understanding of the module content among the child caregivers due to low literacy level.

The formative research found that domestic animals move freely within households which potentially contributes to the spread of pathogens through droppings. In addition, it was noted that the animals were a risk to the few existing handwashing facilities, as they were easily knocked down during animal movements within the household domain.

Considering that most of the existing WASH programmes had little emphasis on food hygiene, this study found that the extension workers (HSAs) and community volunteers had limited capacity to implement food hygiene behaviour change interventions.

3.8.2 Identified key behaviours

With the use of a mixed methods approach, the formative study identified that children were exposed to numerous household contaminants that had the potential of causing diarrhoeal and respiratory infections. For instance, children were observed sitting on bare ground where they touched dirt including putting different objects into their mouth. Child caregivers rarely washed their hands with soap before child feeding, before food preparation and after attending to animal and child faeces. Similarly, the children did not wash their hands with soap where they practiced self – feeding.

Washing of utensils with soap was rarely observed, specifically before use. On some occasions, sand was used as an alternative to wash the utensils instead of soap. Keeping of utensils away from animals and children was very uncommon in the targeted households. The study observed great variation on reheating of stored cooked food before consumption; the food was either warmed to improve taste during eating or not reheated at all. Food was rarely reheated to a recommended safe temperature. This corresponded with microbiological analysis where faecal coliforms and total coliforms were primarily found in stored cooked food that had been kept for more than four hours (overnight) at an ambient temperature. In addition, the presence of *Staphylococcus aureus* in stored cooked food was an indicator of poor hygiene practices related to handwashing and cleaning of utensils. Animal faeces were found in the household environment where children played and sat when eating. In addition, the animals were observed licking utensils and drinking water meant for cooking and washing the utensils.

With the use of the HACCP approach, the study identified key risks of contamination with associated critical control points (CCP) related to complementary food and other family meals. The identified CCPs included cooking, cooling and feeding the children.

With this information from the formative research, priority behaviours to be targeted were identified based on the following:

- Observed prevalence
- Expected impact on food contamination if changed
- Feasibility of change

Therefore, behaviours categorised into the following packages, were identified as critical for an intervention:

1. Handwashing with soap; identified the following four critical times of handwashing:
    - Before food preparation
    - Before eating/ feeding
    - After toilet use
    - After cleaning child's bottom
2. Food hygiene; identified the following:
    - Washing utensils with soap
    - Storing utensils safely
    - Reheating of left-over food
    - Child feeding by the caregivers
3. Faeces management; the following aspects were identified:
    - No open defecation
    - Management of child stools
    - Management of animal stools
4. Household water management; the following were identified:

- Safe water storage systems
- Safe drinking systems

It should be highlighted that the key focus of the study was to evaluate food hygiene behaviours; thus handwashing with soap needed to be incorporated into the intervention as a key area of food hygiene practice. Hence this Thesis focused on the following behaviours: handwashing with soap and food hygiene (i.e. washing utensils with soap, storing utensils safely, reheating left over food and child feeding by the caregiver). Despite indirect focus on faeces management and water management, these were also inextricably linked with handwashing with soap and food hygiene practices, and should therefore be addressed within the content of an intervention.

3.8.3 Identified behavioural factors

With the key behaviours identified in paper 1, the RANAS model of behaviour change was applied to identify the behavioural factors (contextual and psychosocial) for the selected target behaviours (Mosler & Contzen, 2016). The study documented in paper 2 indicated that literacy level, ownership of animals, and presence of handwashing facility and dish racks were contextual factors predicting storage of utensils on an elevated (safe) place and handwashing frequencies. While psychosocial factors, such as time spent to wash utensils with soap, distance to the handwashing facility, and cost for soap, had an influence on effective washing of utensils and handwashing practices. Perceived vulnerability determined effective handwashing and storage of utensils. Perceived social norms and ability estimates were favourable for all the identified behaviours in this study. Promotion of already existing targeted beneficial behaviours should be encouraged among caregivers. Risk perceptions on storage of utensils and handwashing practices should be increased with motivational exercises such as paint games (visual demonstration of cross contamination). Caregivers' technical know-how of local dish rack and tippy tap construction is essential.

The identified food hygiene behaviours have been supported by the contextual factors assessed in the recruited formative research households. Furthermore, the psychosocial factors provides the basis for understanding the immediate drivers behind each practice. Thus, it is important that a holistic approach should be taken into consideration when designing food hygiene interventions in low income household settings.

3.8.4 Designing the food hygiene intervention package

Five key food hygiene related behaviours (1. Handwashing with soap, 2. Washing utensils with soap, 3. Storing utensils safely, 4. Reheating left over food and 5. Child feeding by the caregiver) were identified for prioritization in a community based food hygiene intervention. Thus, the next step was to design a food hygiene intervention package focusing on the identified behaviours using locally available resources. In designing the food hygiene intervention, the contextual and psychosocial factors, including critical control points identified in this formative research, should be taken into consideration while aligning them to the corresponding behaviour change techniques suggested in the RANAS model of behaviour change (Contzen & Mosler, 2015b).

Chapter – 4

Design and delivery of the food hygiene intervention

4.1 Rationale

This chapter describes three key elements of the intervention: 1) design content, 2) the method of content delivery and, 3) method for evaluating the primary outcome. All these elements were grounded in the formative research outlined in Chapter 3.

4.1.1 Overview of Intervention Design Phase

The development of the intervention was guided by the formative research (refer to Chapter 3) which was conducted between February to July 2017 prior to intervention design. Importantly, previous research was also taken into consideration during designing of the intervention (Desai et al., 2015; Gautam et al., 2017b; Islam et al., 2013; Luby et al., 2018b; Touré et al., 2013). Prominently, the WHOs five key behaviours for safe food were critically assessed during intervention development (WHO, 2014). Additionally, the cultural setting of rural Malawi has been taken into consideration, particularly the previous methods that have been used in the delivery of maternal and child health interventions (Manda-Taylor et al., 2017; Rippon et al., 2018; Zimba et al., 2012). These studies emphasized the importance of using existing community structures, women's cluster groups, contextualized dramas and songs in the delivery of health promotion through leveraging social capital and collective efficacy.

The RANAS model of behaviour change (Figure 11) provided theoretical guidance in the development of the intervention based on the critical control points identified by the formative study. These critical control points were then examined in terms of context (social, personal, and environmental), structural barriers, and psychosocial factors (RANAS model) to design specific intervention activities. Specifically, the Behaviour Change Techniques (BCTs) of the RANAS model (Mosler & Contzen, 2016) were used to determine specific activities to address significant behaviour factors identified during formative research in order to bring targeted change.

Table 7 highlights the behavioural factors with corresponding Behaviour Change Techniques (BCTs) of the RANAS model that were identified as significant, if positive change was to happen in the targeted behaviours.

Table 7: Behavioural factors with corresponding BCTS for the identified behaviours

Key hygiene behaviours	Components of the key behaviours	Identified behavioural factors	Corresponding RANAS BCTs
Handwashing with soap	1. Handwashing with soap before food preparation 2. Handwashing with soap before child feeding/eating 3. Handwashing with soap after latrine use 4. Handwashing with soap after cleaning child's bottom	Risk factors (vulnerability, health knowledge)	Present facts and scenarios (BCTs 1 and 2) Inform about and assess personal risk (BCT 3)
		Attitudinal factors (feeling, beliefs about costs and benefits)	Describe feelings about performing and about consequences of the behaviour (BCT 8) Inform about and assess costs and benefits (BCT 5)
		Norm factors (other' behaviour)	Inform about others' behaviour (BCT 9) Prompt public commitment (BCT 10)
		Ability factors (confidence in performance)	Increase confidence in behaviour: performance by providing practical instructions (BCT 15) Provide infrastructure (BCT 16)
		Self-regulation factors (remembering)	Memory aids and environmental prompts (BCT 34)
Food hygiene behaviour	1. Washing utensils with soap	Risk factors (health knowledge)	Provide practical information on behaviour and health outcomes (BCT 1)
		Normative factors (others behaviour)	Inform about others' behaviour (BCT 9) Prompt public commitment (BCT 10)
		Ability factors (confidence in performance)	Increase confidence in behaviour: prompt guided practice (BCT 18)
		Self-regulation factors (remembering)	Memory aids and environmental prompts (BCT 34)
		Risk factors (health knowledge, costs and benefits)	Present facts and scenarios (BCTs 1 and 2).

	2. Safe storage of utensils (keeping on an elevated place)		Inform about and assess costs and benefits (BCT 5)
		Normative factors (others behaviour)	Inform about others' behaviour (BCT 9) Prompt public commitment (BCT 10)
		Ability factors (confidence in performance)	Increase confidence in behaviour: performance by providing practical instructions (BCT 15)
		Self-regulation factors (remembering)	Memory aids and environmental prompts (BCT 34)
	3. Reheating of left-over food	Attitudinal factors (feelings)	Describe feelings about performing and about consequences of the behaviour (BCT 8)
		Normative factors (others behaviour)	Inform about others' behaviour (BCT 9) Prompt public commitment (BCT 10)
		Ability factors (confidence in performance)	Prompt guided practice (BCT 18) Use arguments to bolster self-efficacy (BCT 22)
	4. Feeding of children by the child caregiver	Normative factors (others behaviour)	Inform about others' behaviour (BCT 9) Prompt public commitment (BCT 10)
		Ability factors (confidence in performance and confidence in recovery)	Demonstrate and model behaviour (BCT 17) Prompt coping with relapse (BCT 25)

As indicated in Table 7, formative research found that normative and ability factors were the strongest factors of all the targeted behaviours. This is similar to the findings of previous studies (Lilje et al., 2015; Slekiene & Mosler, 2018). Thus, development of the interventions to improve the targeted behaviours focused primarily on these key factors, while incorporating the other identified factors.

It was also necessary to consider other factors when selecting which adverse behaviours should be targeted for change. Thus, these three factors were included in the selection of the behaviours: 1) prevalence of the behaviours at the household setting, 2) feasibility of the behaviours to change considering cultural and resource constraints, and 3) the expected impact of the changed behaviours on contamination of household food. Consideration of these factors also guided the methodological approach to be applied and emphasized the need for a detailed anthropological approach to understand household daily routines in their natural setting. Taking all of these factors into consideration, the intervention was named '*Banja La Ukhondo'* or "The Hygienic Family' (Figure 15), as the formative research had identified all family members are crucial in bringing change to the food hygiene behaviours at household level.

Figure 15: Banja La Ukhondo (the Hygienic family) logo for the SHARE Intervention Study

4.1.2 The Hygienic Family Design Process

With reference to the identified behavioural factors, the author led the research team in designing specific and complementary modules, examining both how content would be delivered and how it would be framed.

The author led the research team at the Centre for Water, Sanitation, Health and Appropriate Technology Development (WASHTED) based at the University of Malawi's Polytechnic in the development of the intervention, in collaboration with the behaviour change specialists at the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) who provided technical advice in the development of the intervention. The team applied an interactive process in the development of the intervention where participatory (i.e. brainstorming and sharing of ideas), interesting and attractive methods of behaviour change were used, moving away from the traditional, classroom based approach. Activities to be included in the food hygiene intervention package were brainstormed with reference to the BCTs of the RANAS model during the intervention design meeting sessions (Figure 16) that were held weekly, throughout the three months of intervention development. In attendance of the design meeting sessions included three Public Health specialists in WASH, one Anthropologist, one Artist/marketer and two Research field coordinators. In addition, the local context was considered during the development of the intervention package. Thus, views from the Community Health Workers and community members were sought and incorporated in the design of the intervention. Importantly, the intervention was developed to ensure that it was simple and incorporated the use of locally available resources (e.g. use of community coordinators, design of hand washing facilities, etc.) to ensure that it was scalable and sustainable in the long term.

Figure 16: Intervention development creative session in progress

Before implementation, the intervention materials were tested in a village which was not part of the study. Pre-testing of the materials allowed improvements to be made prior to full implementation of the intervention. Pre-testing was conducted in selected rural households of Chikwawa district that had similar characteristics to the intervention households. No incentives were given to the households that participated during pre-testing.

4.2 The Hygienic Family Implementation Model

Key to the successful delivery of the intervention was the implementation model. The design team examined the recommended BCTs and models from both within and outside Malawi from successful community health interventions where they have been proven to be effective in changing health behaviours among community members (Contzen & Mosler, 2013; Pickering et al., 2019). In previous community health interventions (e.g. Maternal and Child Health) conducted in Malawi a high level of success was attained with interventions delivered through women's groups (Lewycka et al., 2010, 2013; Rosato et al., 2010). Similar success using these lines of communication have also been demonstrated in other countries. For example, in Nepal, local women worked together to design and implement an intervention that successfully improved maternal and neonatal health (Manandhar et al., 2004). Similarly in India, with the use of mother groups, neonatal mortality was reduced by 45% (Azad et al., 2010). Thus, community health interventions involving mother groups has the potential to improve child health in low income settings. Further, use of already existing community health structures and approaches is essential if scaling up and sustainability of new health interventions is to be realized. Thus, based on these assessments, the Hygienic Family intervention was designed to be implemented using three levels of engagement and communication: public open days, cluster meetings (women's groups) and household visits.

The open days were conducted at the beginning and at the end of intervention implementation (i.e. in December 2017 and November 2018 respectively). The open days were attended by the village chiefs, targeted child caregivers, community coordinators, community health workers

(HSAs), SHARE research project staff and other interested community members. The purpose of the open days at the beginning of the intervention implementation was to create awareness among community members of the upcoming food hygiene promotion campaign and to lobby for social support from the local leaders (i.e. village chiefs) and the government (i.e. the HSAs). The open days also aimed at generating interest and commitment amongst the child caregivers and the community coordinators. The open days conducted at the end of the intervention implementation aimed at motivating the child caregivers to sustain the adopted new behaviours promoted by the campaign.

The cluster meetings helped bringing the caregivers together to learn and discuss how they would adopt and sustain the promoted behaviours. While household visits were conducted to provide one to one guided practice, observe and encourage use of cues for action and to remind the child caregivers of their commitment in performing the targeted behaviours.

As shown in Figure 17, the 'Hygienic Family' intervention delivery model targeted child caregivers with children under the age of five years who were grouped into clusters, i.e. mothers groups. These clusters formed a focal point of meeting where all child caregivers for a particular cluster were expected to attend training sessions to learn and share experiences pertaining to the targeted food hygiene behaviours.

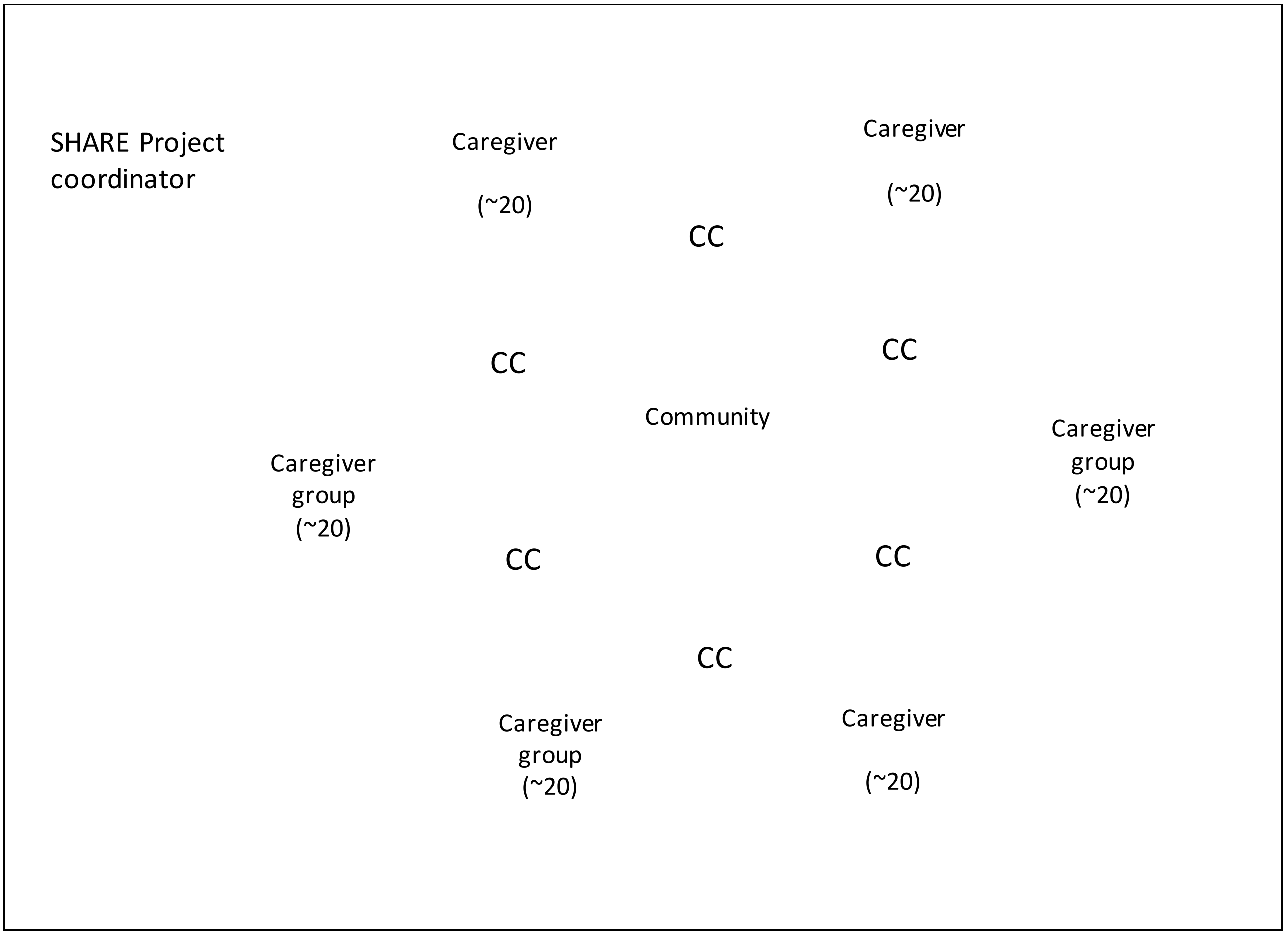

Figure 17: Implementation model for the intervention arm of the study

4.2.1 Community coordinators (CC)

In total, there were 40 clusters in the intervention area; each cluster had a range of 15 – 20 child caregivers. Every cluster was assigned to one female community coordinator (CC) that were recruited through competitive interviews. The community coordinators (n = 40) who facilitated the cluster meetings and conducted household visits were drawn from the study communities and some of them were already serving their communities as community health volunteers through existing structures such as Village Health Committee (VHC). In addition, the coordinators were holders of either the Malawi Junior Certificate of Education (JCE) or the Malawi School Certificate of Education (MSCE) which is an equivalent to the English General Certificate of

Education "O" level. Female volunteers were preferred since child care at household level in rural Malawi is mostly done by the females; this was confirmed during formative research. Further, research has revealed that female field workers find it easier to gain access to some aspects of both men and women's lives than male counterparts (Nader, 1986). During implementation of the intervention, the community coordinators received a monthly monetary incentive of MK20,000 ($27). At the end of the intervention implementation, the community coordinators were given a certificate indicating their experience for future references. In addition, they were given medals in recognition of their support in the research project (Figure 18).

Figure 18: Community coordinators recognized at the end of the intervention implementation

4.2.2 Scheduling

The cluster meetings were held in the afternoon on any day of the week to the preference of the participants (except Saturday and Sunday) in the targeted communities (i.e. in three TAs). Afternoon sessions (i.e. between 2:00pm – 5:00pm) were preferred because the child caregivers were free from household chores including farming activities. The meetings were mainly held at an agreed community church or village chief's meeting ground. A week of cluster meetings was followed by a week of household visits where the community coordinators in collaboration with the local HSAs reinforced the targeted behaviours that were discussed and demonstrated in the cluster meetings (Table 8). In addition, the household visits created a platform for special sessions where the community coordinators provided support to the child caregivers that experienced specific challenges. Each cluster meeting session lasted about 1 to 2 hours, while households visits took almost an hour.

4.2.3 Training

The community coordinators underwent training which was conducted in three phases as indicated in Figure 19:

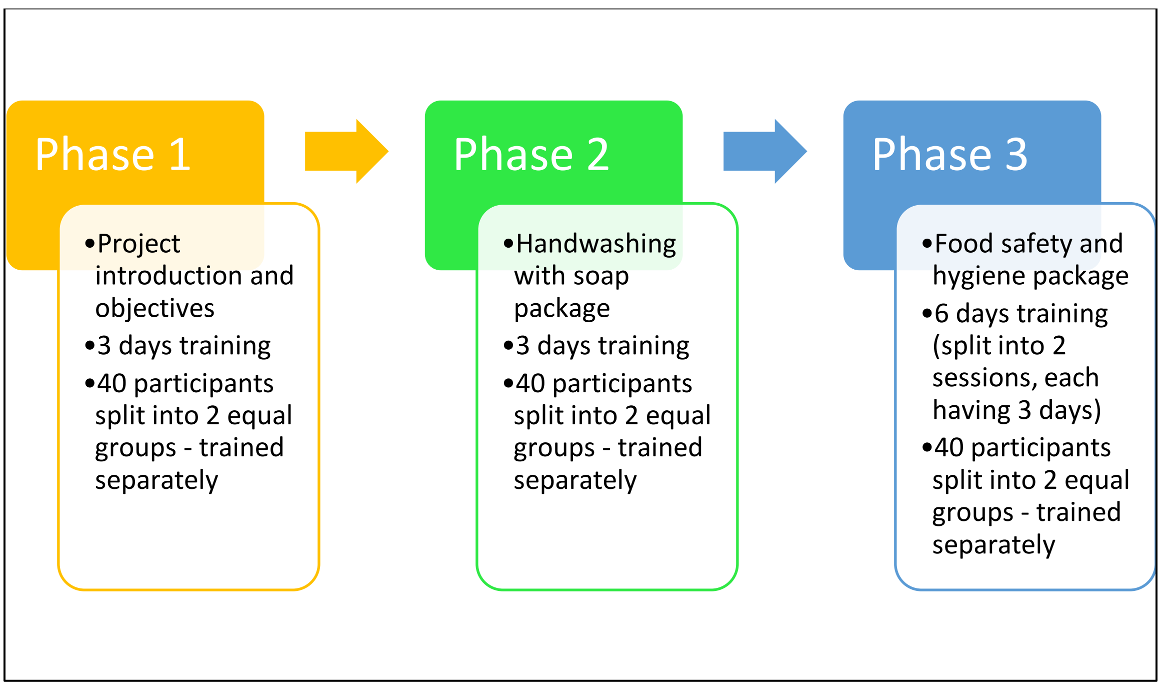

Figure 19: Training phases that were followed during orientation of the community coordinators

Training phase 1:

Phase 1 comprised of introducing the community coordinators to the research project and detailing their roles. The coordinators were grouped into two (each having 20 participants) and were trained separately. Specifically, they were trained on the aims of the research project, concepts about food hygiene at household level, and how to conduct community/cluster meetings and household visits. Importantly, the training also imparted interpersonal and communication skills to the coordinators.

Training phase 2:

This training followed phase 1 training and before implementation of the 'handwashing with soap' package. The community coordinators were provided with knowledge and skills about the handwashing with soap package which had four modules. As with Phase 1, during this training phase, the participants were grouped into two (each having 20 participants) and they were trained separately for three days.

Training phase 3:

Phase 3 training was conducted after implementation of handwashing with soap package. It comprised of equipping the community coordinators with a specific 'food safety and hygiene' package. This package had eight modules, so delivery of the training was divided into two parts; part 1 and 2 which comprised of training the participants with lessons from module 1 to 4, and 5 to 8, respectively. Part 1 training was delivered at the beginning of implementing the 'food safety and hygiene' package. While part 2 training was conducted mid – way through delivery of the food hygiene package; after implementing modules 1 to 4. Again, the training participants were grouped into two (each having 20 participants) during both Part 1 and 2 of the training which was conducted for six days (i.e. each part had three consecutive days of training).

All the training phases applied the participatory approach where by the participants were actively involved through taking part in role playing, demonstrations, and other practical exercises including composing and singing hygiene promotion songs (Figure 20). It should be mentioned that moving away from the traditional classroom based approach ensured that the community coordinators understood the motive and the need to promote the targeted behaviours. It also imparted them with the necessary skills on how they should effectively deliver the key messages to the child caregivers in order to trigger the needed change. Each training phase started with a feedback session on the previous materials and tools to evaluate the implemented package. Such review meetings enabled discussion and helped address challenges encountered during implementation of the preceding intervention package before introducing the new package.

Figure 20: Training of community coordinators in progress

4.2.4 Oversight

Implementation of the research intervention in the targeted households was led by the research group coordinators. As mentioned previously, there were two research group coordinators in the intervention area and one in the control area; all three has a public health background. Their responsibilities included training community coordinators, mobilizing and managing intervention materials at community level, and providing support including supervision to community coordinators during cluster meetings and household visits. They also facilitated monthly feedback meetings with the community coordinators who reported on their performance, discuss lessons learned and brainstorm solutions for any encountered challenges. For instance, it was initially planned that each cluster meeting should be conducted once. However, when it was noticed that some caregivers were missing the meetings due to farming activities, it was resolved that ad hoc cluster meetings should be conducted with those who missed the initially planned meetings at an appropriate time convenient to the child caregivers. At the grassroots level there were also the Government community health workers, primarily HSAs who worked closely with the community coordinators in conducting cluster meetings and household visits.

As with the formative research work, the author took the lead role in the design and delivery of the intervention, including data collection and analysis, and importantly, led the team in evaluating the intervention trial.

4.3 Description of the intervention package

The intervention package focused on key food hygiene behaviours that were identified during formative research, i.e. handwashing with soap and specific food hygiene behaviours. Table 8 summarizes the components of the package and implementation period.

Table 8: Intervention design and implementation period of key behaviours in the intervention package

Key hygiene behaviours	Components of the key behaviours	Intervention period	Number of cluster meetings	Number of household visits
Handwashing with soap	1. Handwashing with soap before food preparation 2. Handwashing with soap before child feeding/eating 3. Handwashing with soap after latrine use 4. Handwashing with soap after cleaning child's bottom	7 weeks	4	3
Food hygiene behaviour	1. Washing utensils with soap 2. Safe storage of utensils (keeping on an elevated place) 3. Reheating of left-over food 4. Feeding of children by the child caregiver	15 weeks	8	7
Implementation and follow up of the behaviours		16 weeks		

The specific intervention package events, activities implemented in the open days, cluster meetings, and household visits are summarized in Table 9. The table also highlights the specific reasons for conducting the selected activities.

Table 9: Summary outline of the intervention package

Intervention	Event	Aim	Activity
Handwashing with soap and food hygiene	First public event/open day	• To sensitize the community members about the food hygiene campaign • To motivate the child caregivers • To lobby support from local chiefs and Government extension workers	• Drama • Speeches • Songs • Public pledge by the child caregivers, community coordinators, local chiefs and Government extension workers
Handwashing with soap	First cluster meeting	• To present situations in everyday life of the caregivers, practically showing how unhygienic handwashing behaviour leads to diarrhoeal disease	• Paint game showing how disease spreads • Demonstration using faecal oral route illustration • How to wash hands with soap practical guide • Hand washing with soap commitment-Paper plate hand painting • Handing out Hand washing with soap score cards
	First household visit	• To reinforce hand washing with soap practice	• Guided practice on demonstrating hand washing with soap practice • Follow up on activities put in place to address hand washing with soap practice
	Second cluster meeting	• To reinforce handwashing with soap practice • To describe feelings about performing and about consequences of the behaviour • To demonstrate handwashing practice and prompt caregivers to pay attention to others' performing the behaviour and its consequences in their everyday life	• Paint game showing how disease spreads • Follow up on disease transmission route • Demonstrate difference between handwashing with and without soap • Singing handwashing with soap song • Demonstrate handwashing with soap steps
	Second household visit	• To reinforce hand washing with soap at household level • To prompt hand washing with soap practice	• Provide guided practice about handwashing with soap • Identifying performers by observing existing practices
	Third cluster meeting	• To demonstrate feelings about performing and about consequences of not handwashing with soap	• Hand washing with soap Dazzy game • Steps for handwashing with soap demonstration • Singing hand washing with soap song

		• To provide information on handwashing facility types • To prompt and support the caregivers to set up handwashing facilities	• With illustrations, demonstrate different handwashing facility types • Practical demonstration on tippy tap construction
	Third household visit	• To prompt handwashing with soap practice	• Provide one to one practical guidance on handwashing facility construction • Caregiver's handwashing observed and corrected where necessary.
	Fourth cluster meeting	• To reinforce correct hand washing with soap practice with the view to these becoming habitual.	• Hand Washing with Soap Glo Germ Experiment • Benefits of Hand washing with Soap-Video • Making hand washing with soap streamers • Reward the performers of handwashing with soap
Food hygiene	First cluster meeting	• To enhance confidence in performance continuation-empower caregivers not to forget hand washing with soap at four critical times • To create affiliation and habit formation	• Paint game to enhance handwashing with soap, distribute bracelets to act as handwashing reminders, each caregiver receive a certificate to indicate their commitment in hand washing with soap
	First household visit	• To prompt washing utensils with soap practice	• Observe caregiver's washing utensils with soap and handwashing with soap at critical times, and corrected where necessary
	Second cluster meeting	• To build confidence in performance-soap , confidence in continuation-time/forgetting and to encourage that others are supporting and are washing utensils with soap all the times-relatives & villagers	• Puzzle game to initiate habit formation about washing utensils with soap, group norms elicited by role models, washing of utensils with soap demonstration
	Second household visit	• To remind and encourage that they can sustain washing utensils with soap	• Assess of use of bracelets, using illustration to demonstrate washing of utensils with soap
	Third cluster meeting	• To strengthen habit formation about washing hands before food preparation, washing utensils with soap before serving and washing hands before feeding • To reinforce cues about washing of utensils with soap	• Cooking demonstration to motivate handwashing before food preparation, washing utensils with soap and washing hands before feeding, card game, child feeding demonstration

	• To point out the pleasant feeling a caregiver gets when they always feed children themselves	
Third household visit	• To observe child feeding practices	• Encourage caregivers about good child feeding practices, remind about washing utensils with soap and handwashing with soap at critical times
Fourth cluster meeting	• To reinforce child feeding practice • To reminding caregivers about handwashing with soap	• Role models to motivate others about caregivers feeding their children. Practical session about consequences of child self – feeding, sing handwashing song.
Fourth household visit	• To observe child feeding practices	• With use of flip chart, motivate caregivers to always feed their children
Fifth cluster meeting	• To improve the food and utensil storage area and reheating of leftover food	• Pass the ball game to demonstrate how food stuffs and leftovers are stored, role play to promote reheating of food, Fixing my food and utensil storage area competition,
Fifth household visit	• To observe if households are changing their storage area setup • To identify performers	• Encourage on how they can change their setup if need be • Demonstrate good storage practice
Sixth cluster meeting	• To reinforce handwashing with soap and reheating of food and improvement of food storage area • To prompt households to keep utensils on raised place • To empower caregivers that others already support the behaviour • To reinforce dish rack construction among caregivers	• Recognize those identified performing well during household visits • Sing handwashing song • Dish rack construction awards • Demonstration on dish rack construction and caregivers commit to own and use dish racks
Sixth household visit	• To observe if the child caregivers have constructed a dish rack • To observe if the child caregivers are using the dish rack	• Provide practical support on dish rack construction • Using illustrations, encourage caregivers on the importance of using dish racks

	Seventh cluster meeting	• To reinforcing use of dish racks, washing of utensils with soap and child feeding practices	• Cardboard shuffling game-keeping utensils on a raised place • Role modeling on use of dish rack, washing utensils with soap and child feeding practices • Food preparation and feeding contest • Distribute bibs
	Seventh household visit	• To observe if households have constructed dish racks • To observe if other sanitary facilities like hand washing systems are still available	• Provide practical support on dish rack construction • Using illustrations, encourage caregivers on the importance of using dish racks and use of bibs
	Eighth cluster meeting	• To reinforcing food hygiene practices: ○ Utensil washing with soap ○ Keeping utensil and food on raised place ○ Child feeding practices ○ Handwashing with soap ○ Reheating of food	• Drama shows • Caregivers with good practice recognized • Banja la ukhondo theme song • Dances and poems by caregivers • Distribute food hygiene buntings
Handwashing with soap and food hygiene	Last public event/open day	• To motivate the child caregivers in the intervention area to continue practicing the targeted behaviours	• Drama • Speeches • Songs • Public pledge by the child caregivers, community coordinators, local chiefs and Government extension workers

Selection of the specific activities outlined in Table 9 for the key targeted behaviours was guided by the Behaviour Change Techniques (BCTs) of the RANAS model (Mosler & Contzen, 2016) as presented in Sections 4.3.1 and 4.3.2. The training manuals used in the delivery of the intervention package are available on https://doi.org/10.17868/76319.

4.3.1 Handwashing with soap

Activities related to handwashing with soap were promoted through four cluster meetings and three household visits which took place in alternating weeks (i.e. two cluster meetings and two household visits per month) (Table 8 and Table 9). The cluster meetings and household visits focused on the identified key handwashing behaviour factors: “vulnerability,” “health knowledge,” “feelings,” “beliefs about costs and benefits,” “confidence in performance (provide infrastructure),” “others’ behaviour” and “remembering” which incorporated Behaviour Change Techniques (BCTs) of the RANAS model (Mosler & Contzen, 2016). The BCTs provided guidance on which specific activities to be included in the intervention as indicated below.

Handwashing with soap behaviour change intervention activities

The first element focused on understanding how disease can transmit via faecal oral routes. This used games, group work and tangible methods to illustrate the risks (Figure 21): including a paint-game which illustrated how disease can spread from person to person, group work to draw the faecal oral transmission route, glo-germ™ with hand washing with water and hand washing with soap and water to show efficacy of germ removal (Hygienic solutions, 2020). These activities covered several aspects of handwashing that targeted “vulnerability,” “health knowledge” and “feelings” factors which incorporated Behaviour Change Techniques (BCTs) 1, 2, 3 and 8 (Mosler & Contzen, 2016), and aimed to build trust and social capital in the group from the outset.

Figure 21: Child caregivers illustrating germ transmission through contaminated hands at a cluster meeting

The second element presented four critical times for handwashing with soap:

1. handwashing with soap after cleaning child’s bottom,
2. after using the latrine,
3. before food preparation,
4. before child feeding/eating).

These four critical times were emphasized through use of poster presentations in cluster meetings where the recipients discussed the “what” and “why” of these four critical times, and this stimulated interesting conversations. Use of posters encouraged the caregivers to talk amongst themselves about the behaviour. This element focused on the factors “health knowledge" and "beliefs about costs and benefits" (BCTs 1, present facts and 7, beliefs about costs and benefits).

The third element targeted "confidence in performance" (BCT 16, "provide infrastructure") which prompted and supported the targeted households to construct handwashing facilities, commonly referred to as a tippy-tap (Figure 22). In addition, it strengthened caregivers' ability to perform the behaviour since the community coordinators demonstrated the recommended steps to properly wash hands with soap (BCT 18, "prompt guided practice"). This activity also proved to others that some caregivers already had handwashing facilities and they were performing the behaviour. Such role models explained to other caregivers how they managed to practice the behaviour in their homes, addressing the factor "others' behaviour" (BCT 9, "inform about others' behaviour").

The fourth element of handwashing with soap behaviour involved provision of cues to action (i.e. bracelets and bibs with handwashing messages) to act as a reminder to caregivers about practicing the behaviour at all the four critical times of handwashing, targeting the factor "remembering" ("use of memory aids and environmental prompts", BCT 34).

Figure 22: A tippy tap handwashing facility in use at one of the intervention households

The fifth activity involved encouraging the caregivers to make public pledge amongst themselves and in front of other community members addressing the factor “others’ behaviour”. Making public commitment to wash hands with soap demonstrated that others are already performing the behaviour (“inform about others’ behaviour”, BCT 9). In addition, the caregivers made the commitment by placing a plate with their hand print (Figure 23) on a noticeable place within their household to show their friends/visitors about their commitment to the behaviour (“making public commitment", BCT 10) which also acted as a reminder to the caregivers to practice the behaviour ("use of memory aids and environmental prompts", BCT 34).

Figure 23: Child caregivers printing their hands in a paper plate to show their commitment to handwashing with soap. The printed paper also acted as a reminder to the caregivers to perform the practice

Furthermore, to appreciate their adherence to the behaviour, caregivers were given a handwashing certificate at the last cluster meeting which they could display within their household, an indication of their commitment to the behaviour. The sixth activity related to caregivers who sustained the behaviours being rewarded (rewards included soap, plates, cups, basins, baskets and buckets), addressing the behaviour factor 'costs and benefits' ("use of subsequent reward," BCT 6).

During door-to-door follow-up household visits, the community coordinators and HSAs reinforced the targeted behaviours that were discussed and demonstrated in the cluster meetings. Household visits allowed community coordinators to assess progress, helped to put lessons into action, and provided support for any challenges that the households might have been facing. Such discussions helped to strengthen trust and social capital among the community members.

4.3.2 Food hygiene

The food hygiene component implemented specific food hygiene activities through eight cluster meetings and seven household visits (i.e. two cluster meetings and two household visits per month) (Table 8 and Table 9). Specifically, four behaviour components were promoted:

1. washing of kitchen utensils with soap,
2. keeping of the kitchen utensils in a safe (elevated) place
3. reheating of left-over food
4. child feeding by the caregiver.

Table 10 presents each food hygiene behaviour component with corresponding behaviour factors identified from the RANAS model of behaviour change (Mosler & Contzen, 2016).

Table 10: Food hygiene behaviour components and associated behaviour factors

No.	Food hygiene behaviour components	Behaviour factors
1	Washing of kitchen utensils with soap	“health knowledge”, “others’ behaviour”, “confidence in performance” and “remembering”
2	Keeping of the kitchen utensils in a safe (elevated) place	“health knowledge,” “costs and benefits,” “others’ behaviour,” “confidence in performance” and “remembering”
3	Reheating of left-over food	“feelings”, “others’ behaviour,” “personal importance” and “confidence in performance”
4	Child feeding by the caregiver	“others’ behaviour”, “confidence in performance” and “confidence in recovery”

The specific activities implemented to promote each behaviour of the food hygiene component are highlighted below.

Washing of kitchen utensils with soap intervention activities

The first activity had a poster and a puzzle game exercise where caregivers were asked to put the cards with different images in the recommended order that is followed when preparing complementary food (i.e. porridge). The game and the poster addressed the factor “health knowledge” through a discussion that highlighted the importance of washing utensils with soap (“present facts”, BCT 1).

The second activity targeted “confidence in performance” and “others’ behaviour” factors through practical demonstrations of the effectiveness of using soap in removing germs from utensils (“demonstrate and model behaviour”, BCT 17). Role models identified during household visits discussed and encouraged others on how they managed to practice the behaviour (“inform about others’ behaviour”, BCT 9 and “prompt to talk to others”, BCT 7) (Figure 24).

Figure 24: Role model demonstrating to fellow child caregivers how she sustains cleaning utensils with soap at her household

The third activity was about encouraging the caregivers to make public commitment related to washing utensils with soap addressing the factor “others’ behaviour”. Making public commitment to wash utensils with soap showed that others are already performing the behaviour (“inform about others’ behaviour”, BCT 9). In addition, the caregivers made the commitment by placing bunting that had washing utensils with soap messaging that was placed within the household (e.g. on the sides of a dish rack) to show their friends/visitors about their commitment to the behaviour (“making public commitment”, BCT 10). The bunting also acted as a reminder to the caregivers to practice the behaviour (“use of memory aids and environmental prompts”, BCT 34).

Keeping kitchen utensils on an elevated place

The first activity was a discussion among the caregivers about two types of poster illustrations i.e. 1. Showing good storage of utensils inside and outside the house (i.e. utensils on a raised place); 2. Showing poor storage of utensils inside and outside the house (i.e. utensils on the floor/ground). The illustrations sparked a debate about hygienic storage of the utensils. It encouraged the caregivers to talk to one another and provided knowledge (“present facts”, BCT 1 and “prompt to talk to others”, BCT 7). Thus, it addressed the behavioural factor ‘health knowledge’.

The second activity was a practical demonstration about dish rack construction to raise the confidence in performance (“provide infrastructure”, BCT 16). The community coordinators guided the caregivers on how they can construct a dish rack with local resources and this was reinforced during household visits (“prompt behavioural practice,” BCT 19) (Figure 25). Those who already had dish racks encouraged others on the benefits and how they managed the behaviour (“inform about others’ behaviour”, BCT 9). In addition, they discussed with their colleagues on how they dealt with relapses to poor habits ("prompt coping with relapse," BCT 25).

The third activity addressed the 'remembering' factor where the caregivers placed bunting on the wall with an image about keeping utensils on an elevated place ("use of memory aids and environmental prompts", BCT 34). In the fourth activity, caregivers made a public pledge by signing a pledge card, committing themselves to always practice the targeted food hygiene behaviours ("making public commitment", BCT 10). In the fifth and final activity, caregivers who sustained the behaviour were rewarded addressing behaviour factor 'costs and benefits' ("use of subsequent reward," BCT 6).

Figure 25: Household kitchen utensils dried on an elevated place (dish rack) in the intervention area

Reheating of left-over food intervention activities

The first activity was about a group discussion emphasizing on the positive feelings associated with reheating of left-over food ("Describe feelings about performing and about consequences of the behaviour", BCT 8). Those who were already reheating their left-over food encouraged others on the benefits and how they managed to perform the behaviour ("inform about others' behaviour", BCT 9). In addition, the role models discussed what motivated them to always reheat their left over food and this included consequences of not performing the behaviour ("Prompt anticipated regret", BCT 12). With the use of poster illustrations, caregivers were encouraged on how they can deal with challenges (e.g. inadequate firewood) that hindered them from reheating left-over food ("confidence in performance" BCTs 18 and 22).

Figure 26: Child caregivers at cluster meeting practicing how they can prepare household food hygienically

Feeding of children by the caregiver intervention activities

With the use of role models, caregivers encouraged one another at cluster meetings that others are already feeding their children (“inform about others’ behaviour”, BCT 9). In addition, caregivers made a commitment in public to continue performing the behaviour (“prompt public commitment,” BCT 10). In cluster meetings, caregivers practically demonstrated to one another how they could achieve the behaviour which included concepts on how to deal with relapses (“Confidence in performance,” BCTs 18 and 25).

4.4 Overall Process Design

Upon identification of the study sites (i.e. intervention and the control area), the study participants were grouped into clusters within their study allocations. In total, there were 50 clusters (i.e. 40 and 10 in the intervention and control areas respectively); each cluster had a range of 15 – 20 child caregivers. The 40 intervention clusters received the food hygiene intervention and no intervention was delivered in the 10 control clusters. Child caregivers within the same village formed a cluster. Child caregivers from neighboring villages formed a cluster if one village had few women with children aged five years and below. As shown in Figure 27, 1180 households were eligible to participate in the study. However, 172 and 8 were excluded from the study as they did not meet the inclusion criteria and declined to participate in the study respectively. Section 4.5 highlights the selection criteria of the participating households. From the remaining 1000 households, 800 and 200 households were allocated to an intervention and control area respectively. At end line evaluation, the study established that 171 and 16 households were lost to follow up from the intervention and control groups respectively.

Behavioural outcomes were measured in 240 intervention households and 80 control households.

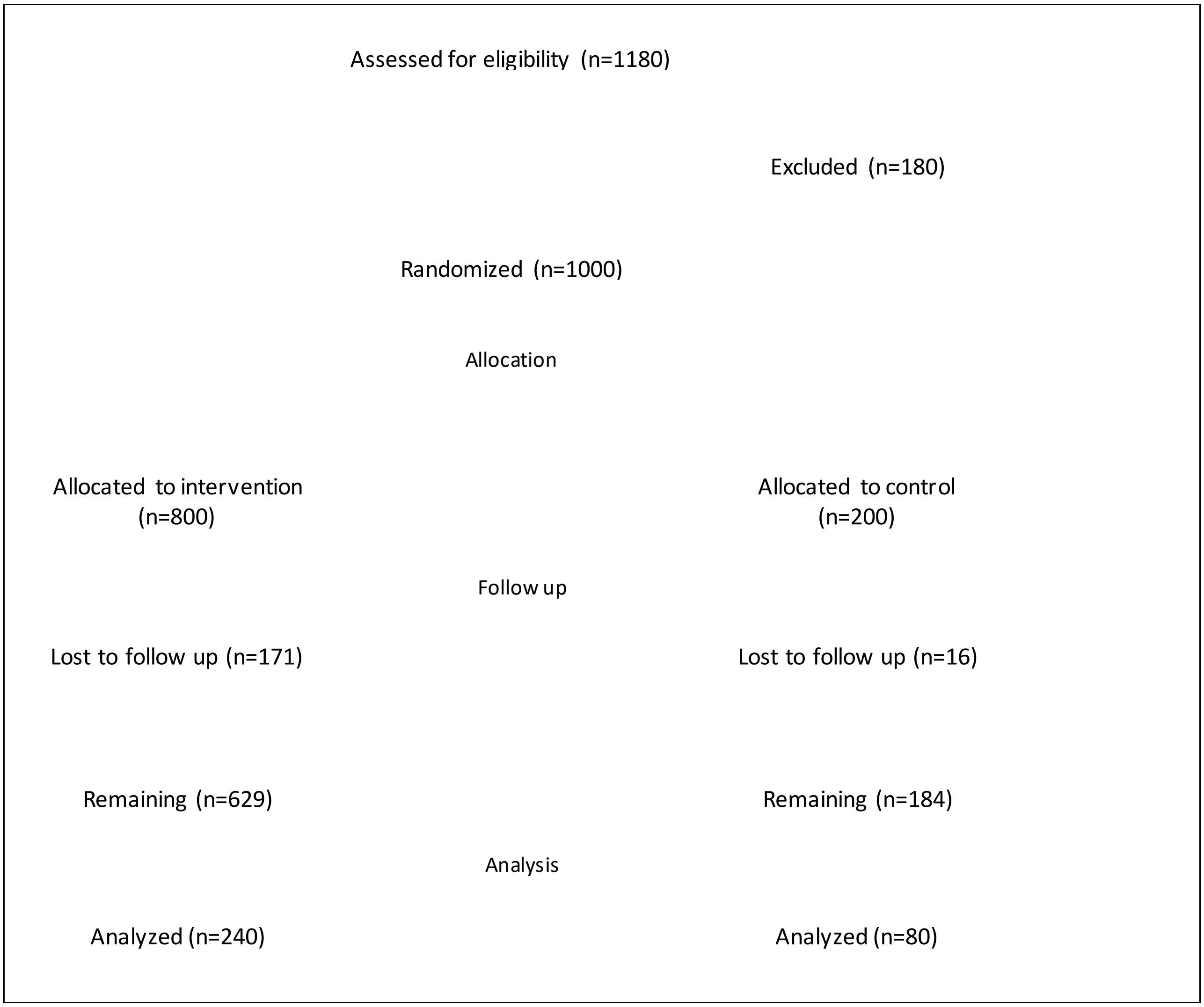

Figure 27: Flow diagram of the study

4.5 Intervention Evaluation Design

This was a Before and After Study with a Control (BAC) which included two surveys, one at baseline, the other as a follow up, in rural Malawi from February 2017 to December 2018. The study design comprised two arms: one was an intervention, while the other served as a control.

The intervention arm received The Hygienic Family behaviour change intervention package, whereas no intervention was implemented among the control households.

The study had 813 households (Treatment area n = 629; Control n = 184) who fully participated in the intervention study. According to Cohen (Cohen, 1992, 2013), an alpha level of 0.05 and small population effect size for analysis of variance (ANOVA) calculations require a sample size of 393 respondents when comparing two groups. However, our study included 320 households that were drawn from the recruited 813 households. Amongst the 320 households, 240 households were from the intervention area while 80 were from the control area. Selection of the 320 households from the 813 households was conducted based on their availability and interviewed at baseline and follow-up surveys as the study was designed to interview the same respondents at both data collection points.

4.5.1 *Inclusion and exclusion criteria*

Table 11 presents criteria that were considered to include or exclude a household in the study.

Table 11: Criteria for the inclusion and exclusion of the study households

Criteria category	**Description of criteria**
Inclusion criteria	Household located in the intervention or control area, A household located in the intervention or control area with a child aged between 4 and 90 weeks at the time of enrolment, A household with a functioning latrine, A household within 500 m radius of a functional borehole
Exclusion criteria	A household not located in the intervention or control area, A household located in the intervention or control area which had no child aged between 4 and 90 weeks at the time of enrolment, Households in villages where pre – testing was conducted.

4.5.2 *Assessment of study outcomes*

The primary outcome measure was the proportion of child caregivers who reported practicing all the targeted behaviours, which was confirmed using structured observations and the hygiene proxy measures that checked the WASH and food hygiene infrastructure (i.e. presence of a handwashing facility, presence of soap and water at the handwashing facility, presence of water and soap at the site where utensils were washed, and presence of a dish rack). The targeted behaviours were: i) child caregivers practicing handwashing with soap before food preparation, before feeding a child (or before eating in case of child self – feeding), after latrine use, and after cleaning child's bottom; ii) child caregivers washing kitchen utensils with soap before use; iii) households that safely kept their kitchen utensils (i.e. kept utensils on an elevated place); iv) households that reheated their left over food and; v) child caregivers who fed their children complementary food.

The primary outcome was measured using two data collection methods (i.e. observations and household surveys) to measure the effectiveness of the intervention. The observation data was necessary to confirm the key findings of the study that were measured through the RANAS model based self – reported household surveys.

1. RANAS model based self – reported household surveys.

Face-to-face structured household surveys, based on the RANAS model, were conducted with all participants to assess their self-reported handwashing and food hygiene practices. The household surveys collected information about sociodemographic characteristics, food hygiene behaviours, psycho-social factors underlying food hygiene behaviours, hygiene proxy measures, and the recipient's participation in the intervention.

Data collectors asked caregivers how often they washed utensils with soap, how often they kept utensils on a raised place, how often they reheated left over food before consumption, how often they fed their child main meals and how often they washed hands with soap at critical times. Washing utensils with soap, keeping utensils on an elevated area, reheating left over food, feeding the child main meals and handwashing with soap were dependent variables, whereas behavioural factors of the RANAS model were independent variables. Questions were also asked to caregivers to assess knowledge about diarrhoeal disease causation, signs, and preventive measures. The ratio of correct answers from the caregivers to all possible answers formed the health knowledge constructs. A single item was used to measure perceived severity, whereas perceived vulnerability of diarrhoea and other psychosocial factors were measured with multiple items. Refer to Appendix 3**: Sample of Household questionnaire based on the RANAS model** for a sample of the RANAS model based questionnaire.

2. Structured observations and hand hygiene audits

To support the reported data, direct observations were conducted in randomly selected households in the control and intervention areas. The observations were conducted from 6 am to 1pm continuously focusing on the targeted behaviours in 87 households (58 from the intervention and 29 from the control) randomly selected from the 320 households that participated in the RANAS model based household surveys (described above) in both groups. A structured observation guide (checklist) and a hand hygiene audit form that was used to capture the observed practices has been included in Appendix 1**: Structured observation form** and Appendix 2**: Hand hygiene audit observation form**.

4.5.3 Statistical analysis for the primary outcome

Refer to Chapter – **5**, section 5.5 and 5.6 (published articles) for more details on how data related to the primary outcome of the study was analysed.

4.5.4 Quality control

Quality control was observed throughout development of data collection tools, as well as during data collection and processing. To ensure reliability of the household structured interviews, the household questionnaire was developed based on the RANAS model (Mosler & Contzen, 2016). The application of the RANAS model in the development of the household questionnaire was discussed with local experts, that assessed the intelligibility of questions and the rating scales involved. Structured household observations were conducted to ensure the validity of the self-reported data collected through structured household questionnaire.

The author was directly involved in training and supervising the research assistants during data collection. A team of five female observers (BSc holders in Social Sciences (n = 1) and Environmental Health (n = 4)) were trained for five days to conduct checklist and structured observations at baseline and follow up data collection points. Similarly, household surveys were conducted by 10 well-trained BSc holders who were experienced research assistants. Both data collection teams were fluent in the local language (Chichewa). In addition, the data collectors were not involved in the intervention implementation.

Pretesting of the data collection tools (i.e. household questionnaire, observation forms and hygiene proxy measure checklist) was conducted before data collection where the research team identified and eliminated irrelevant questions, whereas key questions were further edited for easy understanding. Debriefing sessions were conducted daily during data collection where supervisors and enumerators cross-checked observation forms and questionnaires to ensure that data were complete and consistent in reporting the actual practices. Use of the Open Data Kit (ODK) software during data collection minimized the errors associated with data entry, since the data was directly sent to the online server by the research assistants in the evening of each day of data collection. Importantly, being a cluster randomized trial, the possibility of confounding was minimized.

During delivery of the intervention, both community coordinators and health workers (HSAs) were supported and supervised by treatment arm coordinators to ensure the integrity and fidelity of the content delivered. Each module of the intervention was preceded by a one-week course of training for the community coordinators and HSAs. Completion of the module was also followed up with a review exercise to evaluate the successes and challenges encountered, and outline proposed changes in the content or delivery mechanisms.

4.5.5 Masking

With respect to the nature of the study, the intervention arm of the study knew that they were receiving interventions that aimed at improving household food hygiene behaviours. Thus, it was not possible to mask the study participants in the intervention group about the intervention they were receiving. For the control group, since no intervention was delivered, the study participants were not told about the intervention that was delivered to their counterparts in the intervention area. Spill-over of intervention activities to the control group was minimized by spacing the intervention group 20km away from the control area. To control for observation bias during conduct of the observations, the observers informed the child caregivers that the purpose of the observations were to learn about daily care of their children and not about WASH related behaviours. In addition, the same team of observers was used during both data collection points (i.e. baseline and follow up) and the team was not involved in any way during the design and implementation of the intervention. Similarly, a team of research assistants that collected household data during baseline and follow up surveys had no connections to the intervention implementation. Importantly, both data collection teams did not know which group was the intervention and the control since this was not disclosed during the trainings.

4.5.6 Ethical approval of the study

Ethical approval for the formative research and the randomized cluster before and after trial with a control was received from the University of Malawi's College of Medicine Research Ethics Committee (P.04/16/1935) (Appendix 5**: Ethical approval from University of Malawi College of Medicine to conduct the Food Hygiene Intervention Study**). The study was registered with the Pan African Clinical Trials Registry (PACTR201703002084166). The research assistants explained the aims of the study to the members of the participating households. Consent was then sought from the head of the households and child caregivers of the targeted children. Prior to obtaining consent, potential participants were verbally given information outlining the participant information sheet (Appendix 6**: Participant Information Sheet**) and they were given the chance to ask questions and to discuss any issues. It was made clear that participation in the study was voluntary and that consent to participate could be withdrawn at any time. All data were collected in such a way as to maintain privacy and confidentiality. Participants were given a household identification number that was used as the only participant/household identifier. Any original audio and paper records including consent forms were stored securely in locked cabinets. Only authorized members of the study team and collaborators had access to the records.

Chapter – 5

Effectiveness of an intervention to improve food hygiene behaviours among child caregivers

5.1 Rationale

Chapter 5 provides the key behavioural research findings from the before and after trial with a control (described in Chapter – **4**). Firstly, the chapter highlights the context in which the intervention was implemented, including the fidelity of implementation. This is followed by study findings which examine the difference in observed practices between intervention and control populations, how these correlated with self-reported behaviours and their relative influence on study results. Finally, the chapter presents study results which examine the change in behaviours and their associated behavioural factors among the child caregivers which mediated these observed changes. It then summarizes key outcomes of the intervention implementation, and their implications for future food hygiene programming in similar contexts.

5.2 Implementation of the intervention

The intervention package presented in Chapter – **4** was delivered for a period of nine months (February – October 2018) in the recruited intervention households in rural Chikwawa, Malawi. The intervention was delivered by the community coordinators with support from the community health workers (HSAs) and research project field coordinators (Figure 17). Cluster meetings and household visits were the main channels of engagement and communication used to deliver the intervention. As guided by the theoretical model of the RANAS Behaviour Change Techniques (Mosler & Contzen, 2016), specific activities that were informing, attractive and interesting were developed. The activities not only focused on increasing the child caregiver's knowledge, but also motivating them to appreciate the importance of adopting the targeted behaviours. The intervention had a charming desire to be an ideal 'hygienic family' (Figure 15) that should be admired by other households in the community. Such a family was being depicted as being happy, with healthy children and living in a clean environment, all aspirations identified in the formative research phase.

5.3 Implementation fidelity and dose

The study findings show that all planned activities were delivered by the end of the intervention giving it 100% dose rate. Twenty-nine percent of cluster meetings and 8% of household visits were rescheduled because of low attendance by caregivers and failure of community coordinators to complete all the planned activities for the lesson. However, all planned cluster

meetings, household visits, community volunteer trainings and supervisory visits were delivered (by the end of the intervention) in the two intervention groups of the study.
The intervention team trained community coordinators before they (community coordinators) could train caregivers. These trainings were practical, with community coordinators receiving training as if they were caregivers, and then training others in the group to ensure they understood the content and were able to deliver it competently. Community coordinators received all the trainings that were planned.

Overall, good fidelity was achieved with all the activities being completed for the twelve planned cluster meetings. However, challenges were met in the initial meetings. For example, some activities set for cluster meetings were omitted, some clusters had challenges in finding a place to hang posters during meetings and one meeting encountered a technical problem with the public address system (PA System) that was being used for the delivery of a video on the importance of hand washing. Nevertheless, these issues were addressed in subsequent cluster meetings.

With regard to prompts and nudges used to support sustained behaviour change during the food hygiene module, baby bibs, which were to be used as prompts for safe feeding and handwashing practices, were distributed to caregivers later than planned, which affected the quality of the intervention as some children were older and tried to remove them, or caregivers found that they did not fit the children; hence were not used on a daily basis. Caregivers were also provided with rubber bracelets with a message that reminded them to wash hands at critical times.

However, a problem arose in households between the child caregiver (mother to the targeted child) and their husband, as only one bracelet was provided and both felt they had a right to wear it. This was an indication of positive acceptance of the bracelet at household level, but highlighted the need for the intervention to be more inclusive to achieve whole family buy-in. Before the end of the intervention implementation, it was noted that the handwashing message on the bracelet had faded away. Nevertheless, caregivers indicated that they continued to wear the bracelet which served as a reminder.

5.4 Reach of the intervention

Generally, the intervention was highly accepted by all stakeholders. Acceptability by study participants (caregivers) was evidenced by presence of the bibs (85%), bunting (96%), bracelets (71%), and promoted hygiene proxy measures (section 5.5 and 5.6) amongst the intervention households. In addition, almost all (97%) targeted child caregivers were able to recall all the key messages that were emphasized by the intervention. The intervention was designed to reach 800 participants but by the end of the intervention process evaluation found that there was a 18.7% attrition rate. The primary reason for leaving the study was relocation of study participants from the study area.

The average attendance values at cluster meetings gave an indication of the general participation rates (Table 10). On average participation was at least 50% of the target number, though never close to 100%, indicating that there were consistent absences throughout module delivery. Generally, the child caregivers depended on subsistence farming for their income and this contributed to their absence in some of the cluster meetings when they went out farming. However, this was addressed through deliberate repetition of cluster meetings to ensure that the intervention reached out to all the study participants. In addition, there was reiteration of key messages through subsequent cluster meetings and household visits. It is important that future designs should be flexible in terms of scheduling of meetings with the community members. For instance, project designs should not dictate fixed times when to meet the community members, but rather it should be flexible depending on the availability of the participants. Furthermore, there should be an opportunity to conduct more than one meeting per session.

Overall, caregivers were exposed more to the intervention through household visits. For instance, attendance for the handwashing with soap package was at 70% for households compared with 40.5% for cluster meetings. Similar observations were noted for the food safety and hygiene package (Table 12). This could be attributed to the one to one nature of a visit versus a choice and ability to attend a cluster meeting. In addition, people could be discouraged to attend the cluster meetings if they thought someone would visit them at home for the same purpose. Thus, it is recommendable that similar initiatives in future should have household visits supporting cluster meetings to maximize reach of the intervention.

Table 12: Meeting attendance and Household visits

	Intervention package	**Total held**	**Average attendance**	**% attended none**	**% attended all**

Cluster meetings	Handwashing with Soap	4	2.83	11.5%	40.5%
	Food Safety and Hygiene	8	4.94	14%	17%
Household Visits	Handwashing with Soap	3	2.49	1.5%	70%
	Food Safety and Hygiene	7	6.01	1%	41.5%

Being a ‘Hygienic Family’, the study targeted all household members including men/husbands. For instance, men were invited to attend particular cluster meetings pertaining to their traditional role as key decision makers (WASH inclusive) and provision of infrastructure at household level. Specifically, men were invited to attend cluster meetings where they learned how to construct a dish rack and handwashing facilities using locally available resources. However, at the end of the study, low attendance was experienced from men since they were present in only 35% of the expected cluster meetings. Reasons for low attendance were that men felt out of place because the meetings were dominated by women, and being the main bread winners in the homes, they were busy with farming, doing business and working. Nevertheless, men fully participated whenever available at home during household follow ups conducted by the community coordinators. It has been reported that men’s involvement in child care at household level contradicts social norms about their role (Aubel, 2020); and sometimes their involvement in child care has been associated with mockery (USAID, 2014). As reported elsewhere (Malolo et al., 2020) absence of men in the cluster meetings empowered women to have control over the resources to meet their WASH needs. Caregivers obtained skills and were able to undertake traditionally male allocated tasks, such as construction of WASH facilities where men were not able to support. It is important that interventions should be carefully designed to ensure that social norms discouraging men's participation in community health programmes are addressed properly.

Section 5.5 and 5.6 are articles published in peer reviewed journals and they present key findings of the study in relation to the targeted food hygiene behaviours.

5.5 Self-Reported vs Observed Measures: Validation of Child Caregiver Food Hygiene Practices: (Paper 3)

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Statement of Contributions of Joint Authorship

Kondwani Chidziwisano: (Candidate)

Writing and compilation of manuscript, established methodology, data analysis, preparation of tables and figures

Elizabeth Tilley: (Co - Investigator)

Review and editing the manuscript

Tracy Morse: (Principal Supervisor)

Supervised and assisted with manuscript compilation, reviewing and editing

This section of Chapter 5 is an exact copy of the journal paper referred to above.

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Article

Self-Reported Versus Observed Measures: Validation of Child Caregiver Food Hygiene Practices in Rural Malawi

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Abstract: Few studies have attempted to measure the differences between self-reported and observed food hygiene practices in a household setting. We conducted a study to measure the level of agreement between self-reported and observed food hygiene practices among child caregivers with children under the age of five years in rural Malawi. Fifty-eight child caregivers from an intervention and 29 from a control group were recruited into the study. At the end of a nine-month food hygiene intervention, household observations were conducted followed by self-reported surveys. Overall, practices were found to be more frequently reported than observed in both groups. However, the difference between self-reports and observed practices was minimal in the intervention compared to the control group. The odds ratio results confirm that more desirable practices were observed in the intervention group compared to the control group. Despite the effects of reactivity during observations, the study results imply that the intervention group did not just improve their knowledge, but also translated the messaging into better practice. Researchers and implementing agencies in water, sanitation and hygiene and food hygiene sector should ensure that interventions are context-appropriate, and that effective methods of observation are used to confirm any reported effects of an intervention.

Keywords: food hygiene; direct observations; self-reported; Malawi

1. Introduction

Globally, diarrhoeal diseases cause approximately 424,000 childhood deaths annually [1]. Diarrhoeal infections in low and middle income countries (LMIC) have been associated with 9% of childhood mortality annually [2]. Importantly, 62.2% of diarrhoeal deaths in children under the age of five years in LMIC have been associated with poor water quality, sanitation and hygiene, including the consumption of contaminated food at the household level [3–5]. Frequent childhood diarrhoea has been associated with stunting, which leads to poor cognitive development in children and reduced economic productivity in adulthood [6–8]. In Malawi, high rates of chronic malnutrition have led to 37% of children aged 9–59 months being moderately or severely stunted [9]. In 2016, the Malawi Demographic and Health Survey reported that 22% of children under the age of five had diarrhoea, an increase from the 17.5% reported in 2010 [9,10]. In economically challenged settings, childhood diarrhoea has been linked to various household factors such as faecal contamination of the household environment, animal contact, ingestion of contaminated food and water [11–14].

Food alone has been suggested to be more important than water in the transmission of diarrhoeal pathogens in some low-income settings [4,15–17]. Supplementing breast milk with food, commonly referred to as complementary feeding, at about six months of age [18] has been strongly linked to childhood diarrhoea, due to the foods' unhygienic preparation [11,19–21]. For instance, previous research has reported poor storage of kitchen utensils, storage of left-over food under ambient/high temperature, lack of adequate and/or running water, and contamination of the food preparation areas by domestic animals [11,21,22]. Research in rural Malawi showed that handwashing with soap at critical times, use of clean utensils for serving food and reheating of left-over food are uncommon, and household water and utensils are easily accessed by animals [23–25]. Paradoxically, interventions to reduce childhood diarrhoea have tended to focus on water, sanitation and handwashing practices, with little attention on food hygiene and safety at the household level [26]. Child nutrition programmes have also emphasized exclusive breastfeeding and micronutrient supplementation, with little reference to the associated food hygiene practices that should be in place [27].

Despite reports indicating that food hygiene interventions have been effective in reducing childhood diarrhoea, there has been little effort to improve food hygiene practices in rural household settings of LMIC [28,29]. As such, simple, scalable food hygiene behaviour change interventions have been recommended [28,30–33], which are based and expand on the World Health Organization's (WHO) five key practices of safer food: keep clean; separate raw and cooked; cook thoroughly; keep food at safe temperatures; and use safe water and raw materials [34].

Childcare in rural household setting in low and middle income countries such as Malawi is mostly done by women (also known as child caregivers) that include mothers, aunts and grandmothers to the children [35,36]. The role of these child caregivers in the health of young children cannot be underestimated since they bear the primary responsibility of cleaning and feeding the children. Thus, it is important that they adhere to the WHO key safer food practices [34] to minimize the ingestion of pathogens associated with food.

In determining the impact and uptake of improved food hygiene practices, one of the key challenges is measuring change in practices, particularly taking into consideration the potential gap between reported and actual practices. As interventions invariably impart knowledge with the aim of changing behaviour and associated practices, the use of knowledge-based reporting assessments, such as questionnaires, can be misleading if interpreted to imply that the gained knowledge has translated into practice. Similarly, as much as structured observations have been found to be effective at recording actual practices [37], they may be affected by the presence of an observer [38]. Although both reported and observation methods have been used to measure food hygiene practices, the level of agreement between these methods in food hygiene studies has not been explored in detail [28,39,40]. Previous research conducted in Burkina Faso, Bangladesh, the Democratic Republic of Congo and the United States of America (USA) showed low levels of agreement between reported and observed hand washing and sanitation practices [41–43]. It is important to note that those studies specifically comparing reported and observed food hygiene practices have only been conducted in the USA [44,45], the results of which are not generally applicable to LMICs.

We conducted this study in rural Malawi to measure the level of agreement between the two methods (i.e., observations and interviews) on food hygiene including handwashing practices at the household level. Specifically, we measured the difference between reported and observed practices for both an intervention and control population to validate if the intervention group did not just improve their knowledge, but had also translated the messaging into better practice. This study was undertaken as part of the "Hygienic Family" research project that aimed at improving complementary food hygiene practices in rural households in Malawi [17,46,47].

2. Materials and Methods

2.1. Study Area

The study was conducted in the rural areas of Chikwawa District, located in the southern region of Malawi. With a population of 564,684 (of which 16% are under the age of 5 years) [48], the district is divided into 12 traditional authorities (TAs), and this study was conducted in three TAs. Two TAs served as the intervention area, while the other one served as a control. Selection of the participating three TAs was completed in collaboration with the Health Department of Chikwawa District Council. Details of the selection criteria have been explained in our previous publications [46].

2.2. Study Population and Recruitment

The data used in this paper were collected as part of the end-line survey of a food hygiene intervention [46] that was conducted from November to December 2018 using structured observations and household surveys that included spot checks of water, sanitation and hygiene proxy measures. From the 820 households (Treatment area $n = 629$; Control $n = 184$) who fully participated in the intervention study, including the end-line survey, 58 and 29 households were randomly selected for structured observations in the intervention and control areas, respectively. Self-reported data for this paper were drawn from the household interviews of the same households where the structured observations were conducted. Eligible households had a child under the age of 5 years at the time of data collection, who had participated in the study as either an intervention or control household. The main caregiver of the child was selected as a study participant from each sampled household. The child's mother (91%) was most often identified as the main child caregiver.

2.3. Structured Observations and Household Interviews (Including Household Spot Checks)

At end-line evaluation, the structured observations were conducted within the vicinity of all the sampled 87 households (both in the intervention and control areas). The observations were conducted by six trained female observers (Diploma and BSc holders in Community Development ($n = 1$) or Environmental Health ($n = 5$)); the observers were not involved in the implementation of the intervention and when training them, it was not disclosed as to which one was the intervention and control area. Female observers were chosen because childcare at community level in Malawi is mainly undertaken by women and therefore female observers may gain access to personal information more easily than male ethnographers [49]. To minimize any potential observer effect during observations, the caregivers were told that the purpose of the observations was to learn about childcare without specifying that the focus was on Water, Sanitation and Hygiene (WASH) and food hygiene practices. Observations were conducted from 6 a.m. to 12 p.m. because the formative research findings reveal that the targeted practices were most commonly practiced in the morning hours [24]. With six hours of observation in a small household compound, the observers captured the events of interest.

The practices of interest identified during the formative study were: (1) handwashing with soap at specified critical times (i.e., before child feeding/eating, before food preparation, after cleaning child's bottom and after latrine use); (2) cleaning utensils with soap; (3) safely storing utensils (i.e., keeping on an elevated place); (4) reheating left-over food; and (5) feeding children by the caregiver [24,25]. The selected practices were previously identified as critical to the improvement of WASH and food hygiene practices at household level [23,30,34,50–52]. A structured observation tool [53] guided the development of the pre-coded, structured form that was used to capture all key practices of interest (Supplementary Table S1). In addition, a hand hygiene audit form (Supplementary Table S2) was used to capture handwashing with soap practices. The audit form was structured to capture all handwashing opportunities (including repeated and missed opportunities) performed during the observation period. Each observer conducted about 15 observations in 15 households and they were supervised twice a week by one of the co-principal investigators of the study to ensure consistency in data collection while maintaining data quality.

Two weeks after conducting structured observations, a separate team of enumerators (who were blinded to the treatment allocations) administered a structured questionnaire to the same households to capture information about demographics, child health status, and socio-economic proxy measures. In addition, the questionnaire collected self-reported data from the child caregivers on the same variables (i.e., targeted hygiene practices) that were the focus of the structured observations. At the end of the household interviews, the enumerators conducted spot checks to record hygiene proxy measures such as the presence of a latrine, handwashing facilities (including handwashing facility type, the availability of soap and water), dish racks, domesticated animals, and animal faeces. The interviews were conducted in Chichewa, the local language of the study area. All practice-related questions were in the format of a 5-point Likert scale, since the risk, attitude, norms, ability and self-regulation (RANAS) [54] model of behaviour change was applied in formulating the questions. Example questions are shown in Table 1.

Table 1. Likert scale questions for the targeted practices.

Practices	Questions	Answer Format
Hand washing before child feeding/eating	Before you feed your child food (e.g., porridge), how often do you wash your hands with soap and water?	Never Seldom Sometimes Often Very often
Hand washing after using the toilet	After you defecate, how often do you wash your hands with soap and water?	
Hand washing before food preparation	Before you prepare food, how often do you wash your hands with soap and water?	
Hand washing after cleaning child's bottom	After cleaning child's bottom, how often do you wash your hands with soap and water?	
Washing kitchen utensils with soap	Before you use kitchen utensils, how often do you wash them with soap and water?	
Keeping kitchen utensils on elevated place	Do you keep your kitchen utensils on an elevated place?	Not at all Somewhat Rather Quite a lot Very much
Reheating of left-over food	Do you reheat left over food before being consumed?	
Feeding of child by the caregiver	Do you feed your child main meals (e.g., lunch and breakfast)?	

2.4. Statistical Analysis

Observational and reported data were cleaned and analysed using Microsoft Excel (Microsoft corporation, Redmond, WA, USA) and Statistical Package for Social Sciences (SPSS), version 25.0 (SPSS Inc., Chicago, IL, USA) respectively. Self-reported practices were compared with directly observed practices by conducting odds ratio and Chi-square tests where the confidence level and probability value (p value) were calculated at 95% and <0.05, respectively. The self-reported practice results were divided into the following four categories:

(i) Desirable reported and observed practices: these were desirable self-reported food safety practices confirmed through direct observation;
(ii) Undesirable reported and observed practices: these were undesirable practices observed and then acknowledged through self-report;
(iii) Desirable reported and not observed practices: these were self-reported desirable food safety practices not confirmed through observation;
(iv) Undesirable reported and not observed practices: these were undesirable self-reported food safety practices unconfirmed through direct observation.

For the reported practices measured on the 5-point Likert scale, all responses falling at or below a value of 3 were considered non-performers of the practices and were assigned a "no" response, while those responses at or above 4 were performers of the practices and were assigned "yes" response. Likewise, for the observed practices, participants who were observed as performing the desired practices were assigned a "yes" response, while those who were observed as not performing the desired practices were assigned a "no" response.

2.5. Ethical Approval

The research ethics committee of the University of Malawi's College of Medicine reviewed and approved the study protocol. The study was registered with the Pan African Clinical Trials Registry in March 2017 (PACTR201703002084166). All the study procedures including issues about confidentiality were explained to the caregivers and written informed consent about themselves and that of their children was obtained from them before being included in the study. Upon arrival at the household, the normal rules of the community were followed, where the observer or interviewer greeted members of the household and were offered a place to sit, explained the purpose of the visit, and obtained consent before commencing the observations or interview.

3. Results

3.1. Demographic Characteristics

Demographic characteristics of the sampled households in both the intervention and control areas were broadly similar for the end line survey (Table 2). The majority of the recruited households in both intervention and control areas had pit latrines. However, more pit latrines and handwashing facilities were found in the intervention area compared to the control group. The study established that some households in the control area did not replace their latrines and handwashing facilities that collapsed during the previous rainy season; however, households in the intervention area continued maintaining their sanitary facilities during and after the rains. It was found that in both groups, households maintained and increased availability of soap for various household uses. Nevertheless, there was no soap available on the handwashing facilities in the control area, while its presence was high in the intervention area (81%, $n = 47$). The presence of animals around households was almost the same in both groups. The mean number of people per household was 5.5 and 5.4 in the intervention and control group, respectively, while the mean age of the child caregivers was 30.8 in the intervention and 28.9 in the control group.

Table 2. Demographic characteristics of the study population.

Variable	Intervention (N = 58)	Control (N = 29)
Child caregiver is married	88% (n = 51)	90% (n = 26)
Child caregiver never attended formal education	28% (n = 16)	28% (n = 8)
Household living on <1.90 $/day	88% (n = 51)	83% (n = 24)
Presence of animals at household	65% (n = 38)	61% (n = 18)
Presence of soap at household	91% (n = 53)	83% (n = 24)
Presence of latrine at household	98% (n = 57)	79% (n = 23)
Presence of handwashing facility at household	98% (n = 57)	14% (n = 4)
Soap on handwashing facility	81% (n = 47)	0% (n = 0)

3.2. Observed Handwashing Practice

For handwashing with soap practice, the following pre-specified critical times of handwashing events had been identified as an opportunity to wash hands: before child feeding/eating, before food preparation, after cleaning the child's bottom, and after latrine use. At the end-line survey, the hand hygiene observations revealed that the number of opportunities (opportunities were considered as all occasions when one was expected to wash hands with soap and water before child feeding/eating; before food preparation; after cleaning child's bottom; and after latrine use. An opportunity was registered whether soap, water and handwashing facility were available or not) to wash hands at each sampled household was 600 and 313 opportunities in the intervention and control area, respectively, and therefore, proportional to the study population. The results show that there were more opportunities for handwashing 'before preparing food' and 'before child feeding/eating food' (i.e., main meals and snacks) in both the intervention and control groups (Table 3). However, few opportunities arose to wash hands with soap after cleaning a child's bottom and after latrine use in both groups, which may have been associated with the time of observation.

Table 3. Observed (seized and missed) handwashing opportunities.

Critical Time of Handwashing	Opportunities		
	Intervention (600 Opportunities)	Control (313 Opportunities)	X^2 Test (p-Value)
Before child feeding/eating	44.7% (n = 268)	54.6% (n = 171)	0.391
Before food preparation	42.6% (n = 256)	35.8% (n = 112)	0.541
After cleaning child's bottom	3.7% (n = 22)	3.2% (n = 10)	-
After latrine use	9.0% (n = 54)	6.4% (n = 20)	-

3.3. Handwashing with Soap Practice at Critical Times

As shown in Table 4, the odds ratio and 95% confidence intervals indicate significant differences in instances of observed handwashing between the intervention and control groups. That is, the study participants in the intervention area were more likely to wash hands with soap during the four critical times of handwashing compared to those in the control area.

Table 4. Observed handwashing with soap practice at end-line.

Critical Times of Handwashing with Soap	Study Area		Odds Ratio	CI (95%)
	Intervention	Control		
Before child feeding/eating	43.3% (n = 116)	0.6% (n = 1)	129.7	22.08–5197.5
Before food preparation	47.3% (n = 121)	0% (n = 13)	6.8	3.57–13.9
After cleaning child's bottom	72.8% (n = 16)	10% (n = 1)	24	2.74–558.9
After latrine use	42.6% (n = 23)	5% (n = 1)	14.1	1.90–610.7

n = number (numerator) of occasions the study participants were observed washing hands with soap; the denominator represents the opportunities one was expected to wash hands with soap during the specified critical time of handwashing.

A majority (93.1%, n = 54) of the households in the intervention area had two handwashing facilities positioned near the latrine (43.9%, n = 24) and cooking area (56.1%, n = 30), which made it easier for the child caregivers to wash their hands with soap in at critical times. In contrast, one household (3.4%) in the control area had two handwashing facilities.

3.4. Frequencies of Observed and Reported Food Hygiene and Handwashing Practices

Table 5 compares the frequencies of reported and observed food hygiene and handwashing practices among the child caregivers in the intervention and control area. In both groups, all practices were found to be more frequently reported than observed. The only exception to this was where children were more frequently observed eating without a spoon than was reported in both groups. The study noted almost similar findings between self-reported and observed practices among the intervention group for handwashing with soap after latrine use, handwashing with soap before food preparation, child feeding/eating with hands, covering of left-over food, keeping utensils in an elevated place, and washing of utensils with soap. These results imply that the practices caregivers reported corresponded with those observed. However, amongst the respondents in the control group, the child caregivers over-reported the practices. The exceptions were for children eating porridge without using a spoon and for the feeding of children by the child caregivers (Table 5).

The study found over-reporting of the following practices in both groups: handwashing with soap after cleaning child's bottom, handwashing with soap before child feeding/eating, and reheating of left-over food. However, those in the intervention group over-reported these practices more than the control group respondents (Table 5).

Table 5. Observed and reported food hygiene and handwashing practices at end line survey.

Proxy Measures	Control		Intervention	
	Observed	Reported	Observed	Reported
Handwashing with soap after latrine use	5% (n = 1)	81% (n = 24)	86% (n = 50)	96% (n = 56)
Handwashing with soap after cleaning child's bottom	6% (n = 2)	69% (n = 20)	68% (n = 39)	91% (n = 53)
Handwashing with soap before food preparation	10% (n = 3)	41% (n = 12)	68% (n = 39)	83% (n = 48)
Handwashing with soap before child feeding/eating	3% (n = 1)	61% (n = 35)	43% (n = 25)	95% (n = 55)
Child feeding with hands (not using spoon)	39% (n = 11)	23% (n = 7)	27% (n = 16)	19% (n = 11)
Child fed by caregiver	35% (n = 10)	18% (n = 5)	36% (n = 21)	18% (n = 10)
Left-over food reheated	27% (n = 8)	86% (n = 25)	49% (n = 28)	90% (n = 53)
Left-over food covered	52% (n = 15)	77% (n = 22)	81% (n = 47)	93% (n = 54)
Keeping utensils on an elevated place	7% (n = 2)	29% (n = 8)	83% (n = 48)	93% (n = 54)
Cleaning utensils with soap	24% (n = 7)	79% (n = 23)	75% (n = 44)	88% (n = 51)

Intervention group n= 58; control group n = 29.

3.5. Comparison of Observed and Self-Reported Food Hygiene Practices at Individual Level in the Intervention and Control Area

The self-reported desirable food safety practices not confirmed through observation (false positive) were highest amongst the control participants. For instance, 83% (n = 24) of the control study participants compared to 19% (n = 11) of the intervention participants reported, but were not observed, washing hands with soap before food preparation (Table 6). There were more desirable self-reported food safety practices confirmed through direct observation in the intervention compared to the control group. For instance, 53% (n = 31) of the study participants in the intervention area were observed practicing (i.e., washing utensils with soap) what they reported doing. In contrast, 24% (n = 7) of participants from the control area were observed practicing what they reported doing (i.e., washing utensils with soap). Furthermore, there were more observed and reported undesirable practices amongst the participants in the control area compared to those in the intervention area. For example, 38% (n = 11) of the study participants in the control reported and were observed not washing hands with soap after cleaning a child's bottom but only 7% (n = 4) of subjects from the intervention group were observed and reported not performing the same practice. Importantly, there were some desirable practices which the study participants were observed doing, which they did not self-report during the household interviews. For instance, 22% (n = 13) of the study participants in the intervention area were observed feeding their children main meals (i.e., breakfast and lunch). However, these study participants did not report practicing this practice (Table 6).

Table 6. Observed and self-reported food hygiene and handwashing practices at end line.

	Intervention Area (N = 58)				Control Area (N = 29)			
	(Desirable Reported and Observed)	(Undesirable Reported and Observed)	(Desirable Reported and Not Observed)	(Undesirable Reported and Not Observed)	(Desirable Reported and Observed)	(Undesirable Reported and Observed)	(Desirable Reported and Not Observed)	(Undesirable Reported and Not Observed)
Washing utensils with soap	53% (*n* = 31)	0% (*n* = 0)	45% (*n* = 26)	2% (*n* = 1)	24% (*n* = 7)	0% (*n* = 0)	69% (*n* = 20)	7% (*n* = 2)
Keep utensils on an elevated place	76% (*n* = 44)	0% (*n* = 0)	17% (*n* = 10)	7% (*n* = 4)	14% (*n* = 4)	17% (*n* = 5)	52% (*n* = 15)	17% (*n* = 5)
Reheating of left-over food	31% (*n* = 18)	10% (*n* = 6)	59% (*n* = 34)	0% (*n* = 0)	7% (*n* = 2)	10% (*n* = 3)	79% (*n* = 23)	3% (*n* = 1)
Feeding of children by the caregiver	41% (*n* = 24)	14% (*n* = 8)	22% (*n* = 13)	22% (*n* = 13)	14% (*n* = 4)	28% (*n* = 8)	52% (*n* = 15)	7% (*n* = 2)
HW before child feeding/eating	33% (*n* = 19)	0% (*n* = 0)	48% (*n* = 28)	19% (*n* = 11)	0% (*n* = 0)	28% (*n* = 8)	62% (*n* = 18)	10% (*n* = 3)
HW Before food preparation	64% (*n* = 37)	2% (*n* = 1)	19% (*n* = 11)	16% (*n* = 9)	0% (*n* = 0)	17% (*n* = 5)	83% (*n* = 24)	0% (*n* = 0)
HW After cleaning child's bottom	53% (*n* = 31)	7% (*n* = 4)	38% (*n* = 22)	2% (*n* = 1)	3% (*n* = 1)	38% (*n* = 11)	59% (*n* = 17)	0% (*n* = 0)
HW After latrine use	53% (*n* = 31)	3% (*n* = 2)	43% (*n* = 25)	0% (*n* = 0)	3% (*n* = 1)	41% (*n* = 12)	55% (*n* = 16)	0% (*n* = 0)

Desirable reported and observed practices: these were desirable self-reported food safety practices confirmed through direct observation; Undesirable reported and observed practices: these were undesirable practices observed and then acknowledged through self-report; Desirable reported and not observed practices: these were self-reported desirable food safety practices not confirmed through observation; Undesirable reported and not observed practices: these were undesirable self-reported food safety practices unconfirmed through direct observation.

4. Discussion

This study compared observed and reported findings collected through structured observations and household structured questionnaires regarding practices associated with hand washing, cleaning of utensils with soap, safe storage of utensils (i.e., on an elevated place), reheating of left-over food, and feeding of children by the caregivers in the intervention and control areas. The aim of the study was to the assess validity of data collection methods (i.e., observations and interviews) used in WASH and food hygiene research. With recent trials in WASH being criticized for their findings, which did not establish a relationship between WASH interventions and diarrhoeal reduction/child growth [26,55], ensuring that methods of assessment reflect actual practice is essential. Intervention studies need to be cognizant of using methods that are proven to be effective in promoting children's health, and this requires an accurate understanding of whether the practices have been put into action.

Similarly to previous work [41–43], this study found that participants in the intervention and control groups over-reported targeted practices compared to those observed, demonstrating the effects of social desirability bias. This finding implies that the study participants have hygiene knowledge but tend to report what is desirable, rather than the actual practices they perform. With this in mind, errors associated with over-reporting should be considered when analysing data from self-reported surveys [44]. Similar concerns must also be considered when interpreting observation-based results, as participants may also change their practices if they know that they are being observed. In this study, results about undesirable self-reported food safety practices which were contradicted by the observation of desirable practices on selected practices in both study groups indicate that the study participants changed some of the practices due to the presence of the observer. Conducting observations repeatedly and not revealing the primary purpose of the observation visit have been suggested as possible solutions to address the observer effect [28,41,42]. A study in Burkina Faso confirmed the reliability of repeated observations in addressing the social desirability bias associated with self-reported WASH practices [42].

Our study established that the targeted food hygiene and handwashing practices were more frequently observed and reported by the participants in the intervention group than in the control group. This demonstrates that the intervention not only influenced the level of knowledge, but also the targeted practices among the intervention participants. Similarly, a higher level of food hygiene and safety knowledge was measured in a food safety intervention campaign in Hartford, USA [56]. Nevertheless, the current study established a significant difference between what was reported and observed in both study groups on handwashing with soap before child feeding and reheating of left-over food. The participants knew that it was important to wash hands with soap before feeding their children; however, this was not translated into practice, since most of the targeted children were of an age to self-feed. Under such circumstances, the child caregivers should ensure that their children wash hands with soap before eating. Similarly, despite high knowledge on the importance of reheating left-over food, in reality, challenges in accessing firewood for cooking, and limited time might have contributed to the poor performance of this practice.

In a food safety study conducted in Hartford, USA [44], the agreement of self-reported and observed handwashing practice was low (33%). In our study, the agreement of desirable self-reported food safety practices confirmed through direct observation was higher in all the targeted practices in the intervention group than the control group; there were few undesirable reported and observed practices amongst the intervention participants. A high level of agreement (89%) between self-reported and observed practices was also noted by Kendal et al. [45] in a consumer food behaviour questionnaire validation study. Dharod et al. [56] suggested that the high level of agreement between self-reported and observed practices measured in the study by Kendal et al. [45] could be attributed to the participants' previous exposure to food hygiene and safety interventions. Similarly, the high level of agreements between self-reported and observed practices in our intervention population may be explained by the fact that participants improved their knowledge and skills through the programme of activities and follow-ups [46]. In particular, the follow-up household visits made by the community volunteers motivated respondents to practice the desired practices consistently to support habit formation. The intervention was designed to be context-appropriate, which may have contributed to the change in the targeted practices in the intervention group. Nevertheless, numerous desirable reported and not observed practices amongst the control participants correspond with previous work [57] indicating that child caregivers have high levels of WASH knowledge, but few are translated into practice.

The type of questions to the respondent has an influence on whether the respondents over-report [42]. Likert scale questions, previously applied in other research [58] to measure psychological constructs, were used in this study to improve the understanding of the questions by the study participants. The Likert scale-based questionnaire provided a range of possible answers (five options) for the study participants to choose their specific responses relevant to the questions rather than if the "yes" or "no" type of responses were used.

Although this study demonstrated over-reporting, the observation of the targeted handwashing and food hygiene practices might have influenced how the study participants behaved due to the presence of the observer [37]. To address this problem, the study participants were told that the purpose of the observations was to learn about daily care of their young children. In addition, the observations were conducted for 6 h per household per day, as an extended duration has been associated with reduced reactivity [59]. In our study, observations were not conducted repeatedly per household due to resource (cost and time) constraints. Similar studies in future should consider conducting the observations repeatedly since this has been proven to strengthen the validity and reliability of observations as a data collection method [42]. Such observation studies could also include more than one observer per session to allow all practices to be fully captured for inter-observer analysis. However, the context in which observations take place should be considered to ensure that conducting observations repeatedly with the presence of additional observers in a small space will not lead to a higher level of social desirability bias. The study population was restricted to 87 households in rural Malawi, which is not statistically representative of rural Malawian households. However, this research provides important information about the validity of the information provided by the study participants, which is necessary to determine the effectiveness of an intervention in changing the targeted practices.

This research has established that the study participants in the intervention area were more likely to wash hands with soap at the targeted critical times of handwashing compared to their counterparts in the control group. Increasing the presence of handwashing facilities in the intervention area was related to the increase in performance of the desired handwashing practice. Encouraging the household participants in the intervention area to install a handwashing facility within the cooking area promoted handwashing before food preparation, an activity rarely performed before the implementation of the intervention [25]. Previous research demonstrated that the presence of handwashing facilities encouraged handwashing practice among community members in Ethiopia [60]. Living in an economically challenged environment might have contributed to the failure of the participating households to practice some of the desired practices (e.g., child eating using spoon). The study established that the majority of the sample population had a low level of education and lived in abject poverty (i.e., below World Bank's extreme poverty line of USD 1.90 a day [61]), a situation that demands context-specific health promotion approaches to encourage desired WASH and food hygiene practices.

5. Conclusions

Our study adds to the evidence that community members have a high level of WASH-related knowledge, but that the knowledge is rarely translated into practice. The development and implementation of this context appropriate intervention for hygiene related practices led to a higher level of agreement self-reported and observed practices within the intervention population. Although there may be still the effect of reactivity during observations, this result implies the intervention group did not just improve their knowledge, but also translated the messaging into better practice. Researchers and implementing agencies in WASH and food hygiene sector should ensure that interventions are context-appropriate, and that effective methods of observation are used to confirm any reported effects of an intervention.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/17/12/4498/s1, Table S1: Household structured observation form, Table S2: Hand washing audit form.

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5.6 Improving Complementary Food Hygiene Behaviours Using the RANAS Approach in Malawi: (Paper 4)

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Improving Complementary Food Hygiene Behaviors Using the Risk, Attitude, Norms, Ability, and Self-Regulation Approach in Rural Malawi

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Abstract. The study evaluated the effectiveness of an intervention to improve complementary food hygiene behaviors among child caregivers in rural Malawi. Formative research and intervention development was grounded in the risk, attitude, norms, ability, and self-regulation (RANAS) model and targeted washing hands and kitchen utensils with soap, safe utensil storage, reheating of leftover food, and feeding of children by caregivers. Longitudinal research was applied at baseline and follow-up surveys among 320 caregivers. Determinants of selected behaviors were found, and interventions were developed based on the behavior change techniques aligned with these determinants in the RANAS model. The intervention was delivered over 9 months through group (cluster) meetings and household visits and included demonstrations, games, rewards, and songs. We randomly assigned villages to the control or intervention group. Follow-up results indicated a significant increase in three targeted behaviors (washing kitchen utensils with soap, safe utensil storage, and handwashing with soap) among intervention recipients. Several psychosocial factors differed significantly between the intervention and control groups. Mediation results showed that the intervention had a significant effect on these three targeted behaviors. For handwashing, feelings, others' behavior in the household, and remembering; for washing kitchen utensils, others' behavior in the household and difficulty to get enough soap; for safe utensils storage, others' behavior in the village and remembering mediated the effect of the intervention on the targeted behaviors. The study demonstrated that targeting food hygiene behaviors with a theory-driven behavior change approach using psychosocial factors can improve the behavior of child caregivers in rural Malawi.

INTRODUCTION

Globally, diarrheal diseases are the second leading cause of deaths after acute respiratory infections among children younger than 5 years, with approximately 424, 000 deaths annually.[1] Contaminated water, food, and hands have been associated with diarrhea causation in children.[2–4] Annually, contaminated food alone contributes to 550 million cases of diarrhea, with 230,000 deaths worldwide.[5] Furthermore, it is estimated that 125,000 deaths occur annually among children younger than 5 years in low- and middle-income countries (LMICs) resulting from the burden of food-borne diseases.[5]

Complementary food hygiene practices have been linked to diarrhea among children in low-income settings.[6,7] This has been related to unhygienic food preparation and storage environments such as the method of washing utensils,[8] use of contaminated utensils,[9] poor storage of food (temperature and covering) and utensils,[10,11] presence of animals in food preparation and storage areas,[12] and lack of handwashing at critical times, for example, before food preparation and child feeding.[13–15] Post-cooking activities (e.g., usage of utensils, handwashing, and storage of food) were identified as the main critical areas to potentially control food contamination in rural Malawi.[16,17]

Despite the significant burden of food-borne diseases in LMICs, little effort has been made to understand and improve food hygiene practices in rural household settings. Such an understanding is important for the promotion of child health programs (e.g., nutrition programs) because complementary feeding, water, sanitation, and hygiene (WASH) have been associated with high risk of growth failure.[18–21] Despite this, there has been little emphasis on food hygiene in nutrition or child health programming.[22] Previous research studies have focused on measuring microbial contamination in food with little attention to the development of context-appropriate food hygiene behavior change interventions.[16,17,23–26] Those which developed and tested food hygiene behavior change interventions[13,27–29] focused on increasing the level of knowledge as well as provision of WASH infrastructure and did not address the psychosocial determinants integral to the performance of a behavior.

To bring about a behavior change, psychosocial factors that determine a behavior should be explored to understand why people perform particular health behaviors. Such an assessment provides the basis for the development of subsequent effective behavior change interventions.[30,31] The risk, attitude, norms, ability, and self-regulation (RANAS) model of the behavior change provides detailed psychosocial block factors from a diverse range of psychological theories.[32] Risk factors include the level of understanding and awareness of the person's vulnerability and severity of diseases. It also incorporates health knowledge about disease transmission, prevention options, and personal consequences. Attitudinal factors relate to one's assessment of the beliefs about costs and benefits of a particular behavior and feelings associated with the behavior. Norm factors present the perception of what behavior is performed in society, describing how family and community members, including leaders, approve or disapprove a particular behavior. Ability factors describe an individual's capacity to practice a particular behavior, which includes its uptake, maintenance, and recovery from drawbacks. Finally, self-regulation factors describe one's plan on how to maintain a behavior, and it includes how to address barriers to the implementation of the behavior.

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The RANAS model has been applied successfully to determine behavioral factors as well as to promote water treatment, sanitation, and handwashing practices in LMICs.[33–36] Importantly, we used the RANAS model for the first time to identify and inform an intervention centered on the psychosocial factors influencing complementary food hygiene behaviors in rural Malawi.[37,38]

The present study. The first aim of this study was to demonstrate the effectiveness of an evidence-based intervention on complementary food hygiene behaviors, such as handwashing with soap, washing kitchen utensils with soap, keeping kitchen utensils in a safe (elevated) place, reheating of leftover food, and child feeding by the caregivers. The second aim of the study was to reveal the underlying mechanisms of the behavior change using a theory-based approach and mediation analysis method. This provides information on the most effective elements of the behavior change intervention when addressing complementary food hygiene behaviors.

We addressed the following research questions in our study:

1. Did target behaviors change because of the intervention?
2. Which psychosocial factors changed between intervention and the control group, and how did these vary?
3. Which psychosocial factors changed because of the intervention and, therefore, mediated the change in behavior?

MATERIALS AND METHODS

Study area and design. The longitudinal study included two surveys at baseline and follow-up in rural Malawi between February 2017 and December 2018. The evidence-based intervention package was implemented from February until October 2018. The study design comprised two arms: one was an intervention arm, while the other served as a control. The intervention arm received the "hygienic family" behavior change intervention package, whereas no intervention was implemented among the control households. The study was conducted in Chikwawa district, which is located in the southern region of Malawi. With a population of 564,684 (of which 16% are younger than 5 years),[39] the district is divided into 12 traditional authorities (TAs). This study was conducted in three TAs. Generally, households were made of mud walls (59%), thatch roof (77.1%), and had domesticated animals (61%). Separate kitchens were rare (43%) in the area with the majority of food preparation, including cooking, taking place in the household yard. Similar to other districts in Malawi, fire wood is the main source of energy for cooking in rural Chikwawa (90–95%).[40,41] According to Cohen,[42,43] an alpha level of 0.05 and small population effect size for analysis of variance (ANOVA) calculations require a sample size of 393 respondents when comparing two groups. However, our study included 320 respondents (i.e., 240 households in the intervention area and 80 households from the control area) who were available at baseline and follow-up surveys as the study was designed to interview the same respondents at both data collection points. The inclusion criteria for a household to be part of the study required that it should be located in the intervention or control area, had a functioning latrine, and resided within a 500-m radius of a functioning borehole to ensure that there were no significant variations in access to water or sanitation infrastructure. In addition, eligible households had a child aged between 4 and 90 weeks at the time of enrollment to ensure that children were not neonates and that all children would be younger than 60 months at the end of the intervention period. The age of children was verified, where possible, through birth and/or immunization records supplied by the caregiver and cross-checked by community health workers (health surveillance assistants [HSA]). The main caregiver of the child was selected as a study participant from each household.

Data collection procedure. A team of 10 enumerators were recruited and trained for 1 week before data collection. The enumerators were trained on study goals, practiced interview techniques, and translated the questionnaire into a local language (Chichewa). The training also included principles of human research subjects which ensured that human dignity, integrity, self-determination, rights, and confidentiality were safeguarded during the data collection process. One of the co-principal investigators supervised the data collection in the field throughout the baseline and follow-up surveys.

Measures. Face-to-face structured interviews, based on the RANAS model, were conducted with all participants to assess their self-reported handwashing and food hygiene practices. The questionnaire collected information about sociodemographic characteristics, food hygiene behaviors, psychosocial factors underlying food hygiene behaviors, hygiene proxy measures, and the recipient's participation in the intervention (Table 1, Supplemental Annexes 1–3).

Behavior change intervention package. Development of the intervention was derived from the formative research study conducted between February and July 2017 among 323 child caregivers in villages near and with similar characteristics to the study villages.[37,44] The formative study identified different psychosocial factors for the targeted food hygiene behaviors to be included in an intervention. Thus, the intervention implemented different activities to address specific behavioral factors for each intervention package to facilitate improvement in targeted behaviors.

The complementary food hygiene behavior change intervention package that was implemented under the concept of "Hygienic Family" used cluster meetings and door-to-door household visits on alternating weeks, as the main communication channels[38] because they have been proven to be effective in changing health behaviors.[45–47] The concept of "Hygienic Family" aimed to promote the performance of the targeted behaviors by all family members. The interventions were facilitated by female community volunteers with support from government community health workers and Sanitation and Hygiene Applied Research for Equity (SHARE) project intervention staff. The community volunteers were trained for 2 days before implementing specific behavior change interventions in the cluster meetings. During door-to-door follow-up household visits, the community volunteers and HSAs reinforced the targeted behaviors that were discussed and demonstrated in the cluster meetings. Sanitation and Hygiene Applied Research for Equity project staff, who trained the community volunteers, conducted regular monitoring visits during cluster meetings and household follow-ups. Quarterly feedback meetings were conducted with community volunteers and HSAs to report on their performance,

Table 1
Questions on targeted behaviors

Behaviors	Items	Answer format
Handwashing before eating main meals (e.g., lunch)	Before you feed your child main meals (e.g., lunch), how often do you wash your hands with soap and water? Before your child takes main meals (e.g., lunch), how often does he/she wash hands with soap and water? (asked in case of child self-feeding)	(Almost) at no time–(almost) each time (5-point rating scale)
Handwashing after using the toilet	After you defecate, how often do you wash your hands with soap and water?	
Handwashing before food preparation	Before you prepare food, how often do you wash your hands with soap and water?	
Handwashing before eating snacks	Before you feed your child snacks, how often do you wash your hands with soap and water? Before your child eats snacks, how often does he/she wash hands with soap and water? (asked in case of child self-feeding)	
Handwashing after cleaning child's bottom	After cleaning child's bottom, how often do you wash your hands with soap and water?	
Washing kitchen utensils with soap	Before you use kitchen utensils, how often do you wash them with soap and water?	(Almost) at no time–(almost) each time (5-point rating scale)
Keeping kitchen utensils on an elevated place	Do you keep your kitchen utensils on an elevated place?	Not at all–very much (5-point rating scale)
Reheating of leftover food	Do you reheat leftover food before being consumed?	Not at all–very much (5-point rating scale)
Feeding of child by the caregiver	Do you feed your child main meals (e.g., lunch and breakfast)?	Not at all–very much (5-point rating scale)

Response scales: 5-point rating scale (from "[almost] at no time" to "[almost] each time"; from "not at all" to "very much").

discuss lessons learned, and brainstorm solutions for any encountered challenges.

Implementation of the food hygiene package was conducted through two components, which included 1) handwashing with soap, where activities related to handwashing with soap were promoted through four cluster meetings and three household visits. The cluster meetings and household visits focused on the identified key handwashing behavior factors such as vulnerability, health knowledge, feelings, beliefs about costs and benefits, confidence in performance (provide infrastructure), others' behavior, and remembering, which incorporated behavior change techniques (BCTs) of the RANAS model.[48] 2) The food hygiene component implemented specific food hygiene activities through eight cluster meetings and seven household visits. Specifically, focal components were washing of kitchen utensils with soap, keeping the kitchen utensils in a safe (elevated) place, reheating of leftover food, and child feeding by the caregiver. For washing utensils with soap, the following behavior factors were included: health knowledge, others' behavior, confidence in performance, and remembering. Keeping utensils in a safe place focused on health knowledge, costs and benefits, others' behavior, confidence in performance, and remembering factors. Reheating of left-over food targeted behavior factors about feelings, others' behavior, personal importance, and confidence in performance, whereas feeding of the child by the caregiver included others' behavior, confidence in performance, and confidence in recovery. In total, these components of the intervention were implemented through 12 cluster meetings and 10 household visits. The cluster meetings took place at communal meeting places (e.g., church and village chief's meeting ground) within targeted villages. Design of the intervention package was developed by SHARE project staff with support from the Department of Environmental Social Sciences at Eawag (Swiss Federal Institute of Aquatic Science and Technology) and the SHARE research advisory group that comprised sanitation and hygiene experts in Malawi. Training manuals are available on request, and description of the intervention package has been published elsewhere[38] and briefly described in Supplemental Annex 4.

Ethics. Ethical approval for this study was received from the College of Medicine Research Ethics Committee (P.04/16/1935). The study was registered with the Pan-African Clinical Trials Registry (PACTR201703002084166). Written consent was received from all households willing to participate before allocation of a household identification number and associated barcode.

Statistical analysis of data. The statistical analysis of data was performed using IBM SPSS 23 Statistics software (IBM Corp., Armonk, NY), and the PROCESS macro for SPSS.[49] Frequency analysis, ANOVAs, and *t*-test analysis methods were applied to answer our first and second research questions. The differences between baseline and follow-up data, and between the intervention and control groups were calculated for the targeted behaviors and the underlying psychosocial factors. Comparing the data from the baseline and follow-up surveys, and control and intervention groups revealed significant changes in targeted behaviors and changes in psychosocial factors. Mediation models were used to uncover underlying mechanisms and effects of an intervention on changes in target behaviors. Therefore, we computed a multiple mediation model using the PROCESS macro[49] to answer our third research question. Only psychosocial factors with significant differences between the control and intervention groups were included in three separate multiple mediation models for each targeted behavior. We included intervention design (1 = intervention, 0 = control) as a predictor, changes in psychosocial factors as mediators, and changes in target behaviors as outcomes. The specific indirect (a*b), direct (c′), and total effects (c) of the predictor on outcomes were calculated.

RESULTS

Characteristics of the study population. The analysis of respondent characteristics (N = 320) revealed that all participating caregivers were women, and the average household size was 5.30 (SD = 1.87). The majority of the caregivers were married (88%), and their average age was 28.6 years (SD = 8.6). Most participants (69.9%) had attended primary education, whereas 21.6% had not attended any formal education. All participating households had a child younger than 5 years whose average age was 32.1 months (SD = 6.1).

The monthly income of the respondents in Malawi Kwacha (MK) (1 USD= 740 MKW) varied greatly. It ranged from MK0 to MK9,999 among 34.1%, MK10,000 to MK19,999 among 24.1%, MK20,000 to MK29,999 among 18.4%, MK30,000 to MK39,999 among 14.4%, MK40,000 to MK49,000 among 5%, and over MK50,000 among 4.1%. The wealth index of the respondents included ownership of TV (2.2%), mobile phone (45.3%), electricity (4.4%), running water (1.3%), and bicycle (48.1%). The availability of soap in the households was observed in 86% of the households, and 73.1% of the respondents owned a farming area.

Changes to targeted behaviors. To answer our first research question, did target the behavior change because of the intervention, we compared differences in targeted behaviors between the intervention and control groups between baseline and follow-up surveys. As shown in Table 2, frequency analysis methods, t-tests, and ANOVAs were applied to answer the first question.

The statistical analysis, using t-test mean comparison, revealed significant differences in handwashing with soap, washing kitchen utensils with soap, keeping kitchen utensils in a safe place, and reheating of leftover food at the follow-up in the intervention group. However, there was a slight decrease in feeding children by the caregivers in the intervention group (Table 2). At the follow-up, a significant decrease in keeping kitchen utensils in a safe place was found in the control group. In addition, reheating of leftover food and feeding of children by the caregivers increased considerably among the control group. Nevertheless, there were no significant differences between baseline and follow-up in the control group for the handwashing with soap at key times and in washing kitchen utensils with soap. The ANOVA results showed a significant difference in differences between the intervention and control groups at follow-up in all the five targeted behaviors: handwashing with soap at key times, washing kitchen utensils with soap, keeping kitchen utensils in a safe place, reheating of leftover food, and feeding of children by the caregivers. However, the results for reheating of leftover food and feeding children by the caregivers changed significantly among the control group. As such, these two behaviors were not influenced by the intervention. Hence, only the other three significant targeted behaviors (i.e., handwashing with soap, washing kitchen utensils with soap, and keeping kitchen utensils in a safe place) were included for further analysis.

Changes to the proxy measures about the targeted behaviors. Statistical analysis (chi-square) revealed significant differences (P = 0.000) in differences between the intervention and control groups between baseline and follow-up surveys in all observed hygiene proxy factors: the presence of a handwashing facility (HWF), presence of soap and water at the HWF, presence of water and soap at the site where utensils were washed, and presence of a dish rack (Table 3). The presence of handwashing facilities and dish racks was observed in 95% and 96% of the participating households in the intervention group, respectively, at the end line compared with baseline (43% and 29%, respectively). And, 65% of the intervention households were observed to have water and soap at the dish-washing location, and 77% of the handwashing facilities had both soap and water. This indicated an increase from 31% to 20%, respectively, from what was observed at baseline. However, no significant changes were observed in the control group. Thus, the proxy measures conducted at baseline and follow-up surveys supported what was reported about the change in handwashing and utensil management behaviors among child caregivers in the intervention area.

Changes in psychosocial factors underpinning behaviors such as handwashing with soap, washing kitchen utensils with soap, and keeping kitchen utensils in a safe place. To

TABLE 2

Changes to target behaviors

	Control group (N = 80)			Intervention group (N = 240)			Intervention vs. control
Behavioral factors	M (SD) BL	M (SD) F	M (SD) diff. of mean t-test	M (SD) BL	M (SD) F	M (SD) diff. of mean t-test	Analysis of variance: diff. of mean P-value
Handwashing with soap at critical times	2.98 (1.21)	2.96 (1.00)	−0.02 (1.39)	2.91 (1.22)	4.41 (0.66)	1.49 (1.39)***	0.000
Washing kitchen utensils with soap	3.84 (1.34)	3.84 (1.08)	0.00 (1.57)	3.31 (1.46)	4.58 (0.68)	1.27 (1.64)***	0.000
Keeping kitchen utensils on an elevated place	2.85 (1.98)	2.23 (1.74)	−0.63 (2.48)*	2.08 (1.62)	4.57 (0.91)	2.49 (1.74)***	0.000
Reheating of leftover food	3.30 (1.31)	4.73 (0.67)	1.43 (1.47)***	3.74 (1.19)	4.67 (0.70)	0.93 (1.34)***	0.005
Feeding of child by the caregiver	2.33 (1.41)	2.83 (1.71)	0.50 (2.00)*	2.97 (1.46)	2.71 (1.71)	−0.26 (2.28)	0.008

BL = baseline; F = follow-up; diff = difference; M = mean; SD = standard deviation.
* $P \le 0.05$, ** $P \le 0.01$, *** $P \le 0.001$. Handwashing with soap at key times combined factors such as before eating, after using the toilet, after changing baby napkin, before preparing food, and before eating snack/fruit.

TABLE 3
Changes in proxy measures

Proxy measures	Control (N = 79) BL, % (n)	F, % (n)	Diff., % (n)	Intervention (N = 237) BL, % (n)	F, % (n)	Diff., % (n)	Intervention vs. control Chi-square: diff. P-value
Presence of a HWF	51 (40)	35 (28)	−16 (−12)	43 (102)	95 (225)	52 (123)	0.000
Presence of soap and water at the HWF	24 (19)	18 (14)	−6 (−5)	20 (47)	77 (182)	57 (135)	0.000
Presence of soap and water at the utensil-washing location	28 (22)	24 (19)	−4 (−3)	31 (73)	65 (154)	34 (81)	0.000
Presence of a dish rack	39 (31)	26 (21)	−13 (−10)	29 (69)	96 (228)	67 (159)	0.000

BL = baseline; F = follow-up; diff = difference; HWF = handwashing facility.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$.

answer our second research question, which psychosocial factors changed between the intervention and control groups, and how did these vary, we compared the differences in psychosocial factors underlying handwashing with soap, washing kitchen utensils with soap, and keeping kitchen utensils in a safe place between the intervention and control groups at baseline and follow-up surveys. We used frequency, t-test, and ANOVA mean comparison analysis methods (Tables 4–6).

Changes in psychosocial factors underlying handwashing identified 10 factors with significant differences between the control and intervention groups. Analysis of variance revealed feelings, others' behavior in the household, others' behavior in the village, others' approval, confidence in performance, difficulty to get enough soap for handwashing, distance as a barrier, remembering (pay attention), remembering (forgetting last 24 hours), and commitment as significant factors for the handwashing with soap behavior (Table 4). These significant factors were included in the mediation model as mediators.

The results for changes in psychosocial factors underlying washing kitchen utensils with soap revealed eight factors with a significant difference in differences between the control and intervention groups. As shown in Table 5, ANOVA revealed the following significant factors: others' behavior in the household, others' behavior in the village, confidence in performance, difficulty to get enough water, difficulty to get enough soap, confidence in performance (recovery), remembering (pay attention), and commitment. Again, these changes in psychosocial factors were included for further mediation analysis.

For keeping kitchen utensils in a safe place, 10 factors were identified with a significant difference in differences between the control and intervention groups at the follow-up. According to ANOVA results, behavioral factors such as others'

TABLE 4
Differences in changes in risk, attitude, norms, ability, and self-regulation psychosocial factors explaining handwashing with soap between control and intervention groups

Factor group	Behavioral factors	Control group (N = 80) M (SD) BL	M (SD) F	M (SD) diff. of mean t-test	Intervention group (N = 240) M (SD) BL	M (SD) F	M (SD) diff. of mean t-test	Intervention vs. control group Analysis of variance: diff. of mean P-value
Risk factors	Vulnerability	1.68 (0.47)	3.24 (1.71)	1.56 (1.78)	1.75 (0.43)	2.84 (1.86)	1.09 (1.93)	0.054
	Severity	4.69 (0.8)	4.88 (0.43)	0.19 (0.8)	4.52 (1.09)	4.85 (0.55)	0.33 (1.19)	0.337
	Health knowledge	7.13 (2.32)	7.38 (1.85)	0.25 (2.88)	7.52 (2.62)	7.85 (2.01)	0.33 (3.47)	0.846
Attitude factors	Belief: effort	1.11 (0.64)	1.13 (0.51)	0.02 (0.77)	1.15 (0.66)	1.12 (0.51)	−0.03 (0.85)	0.669
	Belief: time consuming	1.08 (0.47)	1.14 (0.47)	0.06 (0.66)	1.13 (0.58)	1.12 (0.56)	−0.01 (0.83)	0.462
	Belief: expensive	1.84 (1.44)	1.98 (1.49)	0.14 (2.1)	1.73 (1.35)	1.58 (1.09)	−0.15 (1.83)	0.228
	Belief: certain prevention	4.59 (0.92)	4.35 (1.2)	−0.24 (1.54)	4.63 (0.84)	4.67 (0.88)	0.04 (1.20)	0.112
	Feelings (like)	3.66 (1.35)	3.71 (1.17)	0.05 (1.69)	3.58 (1.39)	4.61 (0.76)	1.03 (1.49)	0.000***
Norm factors	Others' behavior in the household	3.75 (1.38)	3.18 (1.34)	−0.57 (1.89)	3.14 (1.47)	4.28 (1.05)	1.14 (1.82)	0.000***
	Others' behavior in the village	2.78 (1.06)	3.18 (1.34)	0.4 (1.63)	2.52 (0.98)	4.28 (1.05)	1.76 (1.45)	0.000***
	Others approval	4.68 (0.76)	4.36 (1.14)	−0.32 (1.36)	4.52 (0.96)	4.77 (0.66)	0.25 (1.17)	0.000***
Ability factors	Confidence in performance	4.43 (1.12)	4.06 (1.14)	−0.37 (1.68)	3.99 (1.44)	4.69 (0.68)	0.70 (1.56)	0.000***
	Difficulty getting water	1.05 (0.27)	1.08 (0.38)	0.03 (0.45)	1.13 (0.64)	1.23 (0.78)	0.10 (1.03)	0.548
	Difficulty getting soap	2.09 (1.45)	2.23 (1.28)	0.14 (1.9)	2.02 (1.51)	1.69 (1.04)	−0.33 (1.85)	0.048*
	Difficulty getting time	1.25 (0.77)	1.13 (0.56)	−0.12 (0.75)	1.25 (0.82)	1.20 (0.0.70)	−0.05 (1.08)	0.566
	Barrier: distance	4.13 (1.4)	3.91 (1.21)	−0.22 (1.94)	3.74 (1.53)	4.61 (0.86)	0.87 (1.75)	0.000***
Self-regulation factors	Remembering (pay attention)	3.78 (1.54)	3.91 (1.06)	0.13 (1.88)	3.36 (1.57)	4.59 (0.80)	1.23 (1.68)	0.000***
	Remembering (forgetting last 24 hours)	2.00 (1.30)	2.51 (1.51)	0.51 (1.94)	2.38 (1.51)	1.44 (0.99)	−0.94 (1.80)	0.000***
	Commitment (important)	4.88 (0.49)	4.68 (0.88)	−0.20 (1.05)	4.85 (0.54)	4.82 (0.63)	−0.03 (0.84)	0.132
	Commitment (commitment)	4.63 (0.85)	4.19 (1.08)	−0.44 (1.38)	4.48 (1.05)	4.82 (0.52)	0.34 (1.20)	0.000***

BL = baseline; F = follow-up; diff. = difference.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$. All questions included 5-point rating scales and response choices from "1 = not at all" to "5 = very much." Health knowledge: sum scale (0–13).

TABLE 5

Differences in changes in risk, attitude, norms, ability, and self-regulation psychosocial factors explaining washing kitchen utensils with soap between control and intervention groups

		Control group (N = 80)			Intervention group (N = 240)			Intervention vs. control group
Factor group	Behavioral factors	M (SD) BL	M (SD) F	M (SD) diff. of mean	M (SD) BL	M (SD) F	M (SD) diff. of mean	Analysis of variance: diff. of mean P-value
Risk factors	Vulnerability	1.68 (0.47)	3.24 (1.71)	1.56 (1.77)	1.75 (0.43)	2.84 (1.86)	1.09 (1.93)	0.054
	Severity	4.69 (0.80)	4.88 (0.43)	0.19 (0.79)	4.52 (1.09)	4.85 (0.0.55)	0.33 (1.19)	0.337
	Health knowledge	7.13 (2.32)	7.38 (1.85)	0.25 (2.88)	7.52 (2.62)	7.85 (2.01)	0.33 (3.47)	0.846
Attitude factors	Belief: effort	1.11 (0.50)	1.13 (0.54)	0.02 (0.75)	1.13 (0.50)	1.14 (0.55)	0.01 (0.75)	0.932
	Belief: time consuming	1.23 (0.69)	1.2 (0.62)	−0.03 (0.93)	1.22 (0.65)	1.23 (0.75)	0.01 (1.03)	0.797
	Belief: pleasant	4.79 (0.72)	4.65 (0.96)	−0.14 (1.11)	4.50 (1.03)	4.63 (1.04)	0.13 (1.39)	0.133
Norm factors	Others' behavior in the household	3.24 (1.33)	3.23 (0.98)	−0.01 (1.56)	2.74 (1.16)	3.73 (1.01)	0.99 (1.49)	0.000***
	Others' behavior in the village	3.19 (0.99)	3.24 (0.89)	0.05 (1.17)	2.55 (0.90)	3.53 (0.84)	0.98 (1.16)	0.000***
	Others' approval	3.55 (1.73)	3.73 (1.58)	0.18 (2.18)	3.72 (1.63)	4.29 (1.18)	0.57 (2.00)	0.132
	Personal obligation	2.54 (1.82)	3.35 (1.68)	0.81 (2.17)	2.35 (1.78)	3.43 (1.75)	1.08 (2.29)	0.354
Ability factors	Confidence in performance	4.25 (1.42)	3.83 (1.27)	−0.42 (1.98)	3.64 (1.60)	4.60 (0.83)	0.96 (1.66)	0.000***
	Difficulty getting water	4.08 (1.50)	4.08 (1.27)	0.00 (1.92)	3.7 (1.53)	4.68 (0.76)	0.98 (1.66)	0.000***
	Difficulty getting soap	2.74 (1.06)	2.58 (1.21)	−0.16 (1.50)	2.92 (1.21)	1.74 (0.90)	−1.18 (1.90)	0.000***
	Confidence in performance (recovery)	4.56 (0.93)	4.23 (1.03)	−0.33* (1.48)	4.05 (1.37)	4.69 (0.73)	0.64 (1.52)	0.000***
Self-regulation factors	Remembering (pay attention)	3.55 (1.73)	3.9 (1.19)	0.35 (1.90)	3.72 (1.63)	4.62 (0.73)	0.90 (1.75)	0.018*
	Remembering (forgetting last 24 hours)	3.95 (1.35)	1.58 (1.18)	−2.38 (1.86)	3.45 (1.51)	1.36 (0.89)	−2.09 (1.74)	0.210
	Commitment (importance)	4.74 (0.84)	4.74 (0.74)	0.00 (1.0)	4.86 (0.54)	4.83 (0.54)	−0.03 (0.79)	0.732
	Commitment (commitment)	3.98 (1.56)	4.39 (0.99)	0.41 (1.91)	3.66 (1.69)	4.72 (0.70)	1.06 (1.78)	0.006**

BL = baseline; F = follow-up; diff = difference.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$. All questions included 5-point rating scales and response choices from "1 = not at all" to "5 = very much." Health knowledge: sum scale (0–13).

behavior in the village, others' approval, personal obligation, confidence in performance (hurry), confidence in performance (no place), confidence in performance (cannot do), confidence in performance (recovery), remembering (pay attention), remembering (forgetting last 24 hours), and commitment (importance) were significant for the behavior of keeping kitchen utensils in a safe place (Table 6). Thus, these significant factors were included for further multiple mediation analysis.

Changes in psychosocial factors as mediators. To answer our third research question, which psychosocial factors changed because of the intervention and, therefore, changed the behaviors, three multiple mediations were computed for the behaviors of handwashing with soap, washing kitchen utensils with soap, and keeping kitchen utensils in a safe place. In our multiple mediation models, intervention (yes/no) was included as predictors, changes in psychosocial factors as mediators, and changes in the target behavior as outcomes. Only factors with a significant difference in differences between the control and intervention groups were selected for mediation analysis as shown in Figures 1–3. Our calculations included specific indirect (a*b), direct (c′), and total effects (c) of the intervention on changes to targeted behaviors. The specific indirect effects (a*b) are defined as the effects of the intervention (predictor X) via psychosocial factors (mediators M) on targeted behaviors (outcome Y). The direct effect (c′) is defined as the effect of intervention on changes to targeted behaviors when all mediators are included in the model. The total effects (c) include all factors calculated in the mediation model.

Our findings from multiple mediation calculations suggest significant specific indirect effects of the intervention on handwashing with soap in the following four psychosocial factors (factors marked gray in Figure 1): feelings (b = 0.2049, [CI: 0.0990–0.3458]), others' behavior household (b = 0.2850, [CI: 0.1120–0.4854]), remembering (pay attention) (b = 0.1304, [CI: 0.0366–0.2530]), and remembering (forgetting last 24 hours) (b = 0.2337, [CI: 0.1112–0.3794]). That is, these factors mediated the relationship between intervention and changes in handwashing with soap at key times.

Factors such as others' behavior in the village, others' approval or disapproval, confidence in performance, difficulty to get enough soap, distance as a barrier, and commitment did not explain handwashing (path "b" not significant). Thus, though these factors did not bring any significant change to the behavior, they were influenced by the intervention (path "a" significant).

Multiple mediation models for the effects of the intervention on changes in washing kitchen utensils with soap revealed significant specific indirect effects in two psychosocial factors (factors marked grey in Figure 2): others' behavior household (b = 0.1574, [CI: 0.0461–0.3019]) and difficulty in having enough soap (b = 0.2367, [CI: 0.1038–0.3986]). Meaning that, these factors mediated the effects of the intervention on washing kitchen utensils with soap behavior.

Psychosocial factors such as others' behavior in the village, confidence in performance, difficulty in having enough water, confidence in performance (recovery), remembering (paying attention), and commitment were not predictors of washing kitchen utensils with soap (path "b" not significant). However, as shown in path "a," the intervention also significantly influenced these factors, despite being irrelevant in changing the behavior (path "a" significant).

Multiple mediation analysis results for the effects of the intervention on changes in keeping kitchen utensils in a safe place revealed significant specific indirect effects in three psychosocial factors (factors marked gray in Figure 3): others' behavior in the village (b = 0.3507, [CI: 0.0825–0.6260]), remembering (paying attention) (b = 0.1962, [CI: 0.0349–0.3878]), and remembering (forgetting last 24 hours) (b = 0.2635, [CI: 0.0853–0.4685]). Thus,

Table 6

Differences in changes in risk, attitude, norms, ability, and self-regulation psychosocial factors explaining keeping kitchen utensils in a safe place between control and intervention groups

		Control group (N = 80)			Intervention group (N = 240)			Intervention vs. control
Factor group	Behavioral factors	M (SD) BL	M (SD) F	M (SD) diff. of mean	M (SD) BL	M (SD) F	M (SD) diff. of mean	analysis of variance: diff. of mean P-value
Risk factors	Vulnerability	1.68 (0.47)	3.24 (1.71)	1.56 (1.77)	1.75 (0.43)	2.84 (1.86)	1.09 (1.93)	0.054
	Severity	4.69 (0.80)	4.88 (0.43)	0.19 (0.79)	4.52 (1.09)	4.85 (0.0.55)	0.33 (1.19)	0.337
	Health knowledge	7.13 (2.32)	7.38 (1.85)	0.25 (2.88)	7.52 (2.62)	7.85 (2.01)	0.33 (3.47)	0.846
Attitude factors	Belief: effort	1.1 (0.52)	1.14 (0.49)	0.04 (0.74)	1.19 (0.0.65)	1.10 (0.49)	−0.09 (0.81)	0.207
	Belief: time consuming	1.1 (0.34)	1.23 (0.78)	0.13 (0.86)	1.28 (0.82)	1.20 (0.75)	−0.08 (1.13)	0.149
	Belief: pleasant	4.44 (1.04)	4.53 (1.02)	0.09 (1.45)	4.44 (1.18)	4.69 (0.90)	0.25 (1.52)	0.403
Norm factors	Others' behavior in the household	4.08 (1.33)	4.15 (1.19)	0.07 (1.87)	4.12 (1.29)	4.58 (0.79)	0.46 (1.50)	0.059
	Others' behavior in the village	2.68 (1.11)	2.48 (0.89)	−0.2 (1.36)	2.30 (0.81)	3.33 (0.84)	1.03 (1.12)	0.000***
	Others' approval	4.01 (1.46)	3.30 (1.56)	−0.71 (2.094)	3.86 (1.53)	4.25 (1.23)	0.39 (1.91)	0.000***
	Personal obligation	2.56 (1.81)	2.99 (1.66)	0.43 (2.18)	2.41 (1.78)	3.54 (1.73)	1.13 (2.55)	0.028*
Ability factors	Confidence in performance (hurry)	3.88 (1.62)	3.83 (1.27)	−0.05 (2.11)	3.38 (1.71)	4.60 (0.83)	1.22 (1.82)	0.000***
	Confidence in performance (no place)	4.03 (1.41)	3.98 (1.21)	−0.05 (1.88)	3.71 (1.56)	4.7 (0.73)	0.99 (1.70)	0.000***
	Confidence in performance (cannot do)	2.61 (1.48)	3.25 (1.61)	0.64 (2.29)	2.31 (1.06)	1.52 (0.94)	−0.79 (1.49)	0.000***
	Confidence in performance (recovery)	4.29 (1.29)	3.95 (1.26)	−0.34 (0.00)	3.95 (1.47)	4.63 (0.73)	0.68 (0.00)	0.000***
Self-regulation factors	Remembering (pay attention)	2.61 (1.82)	2.95 (1.71)	0.34 (2.50)	2.75 (1.75)	4.72 (0.74)	1.97 (1.93)	0.000***
	Remembering (forgetting last 24 hours)	2.63 (1.37)	2.76 (1.78)	0.13 (2.30)	2.42 (1.18)	1.38 (0.95)	−1.04 (1.47)	0.000***
	Commitment (importance)	4.73 (0.76)	4.66 (0.79)	−0.07 (1.12	4.61 (0.92)	4.88 (0.46)	0.27 (1.03)	0.015*
	Commitment (commitment)	3.36 (1.79)	4.3 (1.06)	0.94 (2.24)	3.56 (1.76)	4.84 (0.50)	1.28 (1.81)	0.175

diff. = difference; BL = baseline; F = follow up.
* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$. All questions included 5-point rating scales and response choices from "1 = not at all" to "5 = very much." Health knowledge: sum scale (0–13).

these factors were mediators on the effects of the intervention on keeping kitchen utensils in a safe place.

Psychosocial factors including others' approval, personal obligation, confidence in performance (hurry), confidence in performance (no place), confidence in performance (cannot do), confidence in performance (recovery), and commitment (importance) did not explain keeping kitchen utensils in a safe place behavior (path "b" not significant). Hence, the intervention influenced these psychosocial factors. However, they were not relevant in changing the behavior (path "a" significant).

DISCUSSION

Interpretation of study results. This study investigated the effectiveness of an intervention package derived from evidence-based data using the RANAS model of the behavior

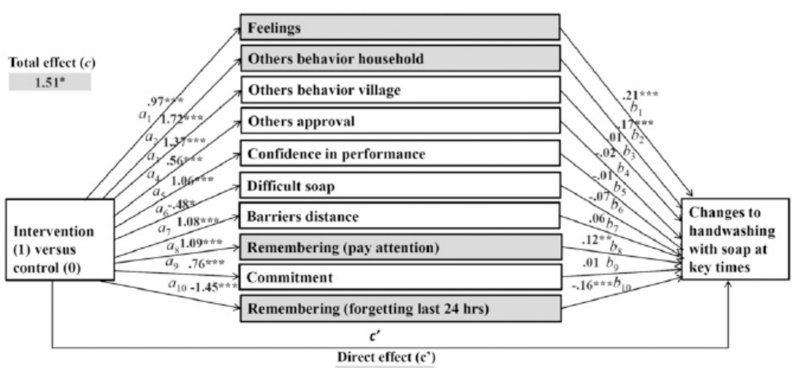

Figure 1. Multiple mediation: effects of intervention on changes to handwashing with soap via changes in psychosocial factors (mediators).

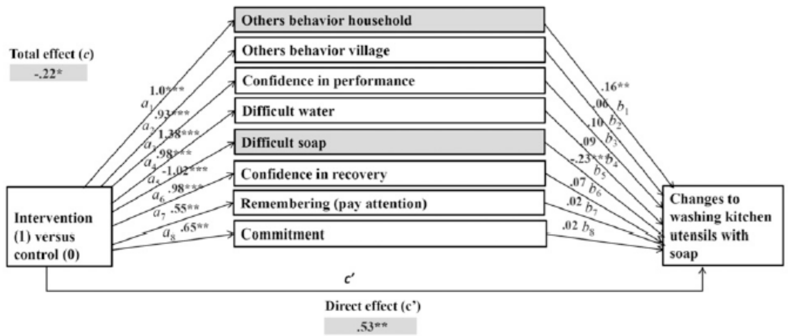

FIGURE 2. Multiple mediation: effects of intervention on changes to washing kitchen utensils with soap via changes in psychosocial factors (mediators).

change[32,48] that aimed to improve complementary food hygiene practices in rural Malawi. The evidence-based interventions targeted the following food hygiene behaviors: handwashing with soap at key times, washing kitchen utensils with soap, keeping kitchen utensils in a safe place, reheating of leftover food, and feeding of children by caregivers. This study aimed to identify the underlying mechanisms of the intervention on target behaviors using the multiple mediation analysis method[49] to identify which interventions were most effective in changing the behaviors. The study results have shown that most households in the study setting live below the World Bank's extreme poverty line of USD 1.90 a day,[50] a situation that requires further attention and context-appropriate health promotion strategies.

The results of the study for the first research question, did complementary food hygiene behaviors change because of the intervention, suggest a significant increase in three target behaviors after the intervention: handwashing with soap, washing kitchen utensils with soap, and keeping kitchen utensils in a safe place. These results confirmed the effectiveness of the RANAS model in developing and testing evidence-based interventions for food hygiene behaviors, the first of its kind. These findings are also in line with previous research examining the effects of behavior change interventions on hygiene, for example, handwashing with soap.[51–53] On the proxy measures (availability of an HWF, availability of soap and water at the HWF, and availability of an elevated place for keeping kitchen utensils), the study results showed a significant increase after intervention implementation in the treatment group. This increase in WASH infrastructure was as a result of promotion activities that encouraged the caregivers to install the facilities. Previous research suggests that availability of infrastructure is a strong predictor for successful performance of desired target behaviors.[54]

The study results for the second research question, which psychosocial factors vary between the intervention and control groups, revealed a significant difference in differences between the intervention and control groups at the time of follow-up survey. These factors were included in further mediation models to investigate the most effective interventions and to uncover underlying mechanisms of the effects on targeted food hygiene behaviors via psychosocial factors.

Establishing a relationship between the intervention and changes in the targeted behavior does not translate to an understanding of exactly how interventions affect the behavior change.[49] As such, mediation models can be used to uncover underlying mechanisms of the evidence-based behavior change in the public health sector.[36,52,55] The results of this mediation analysis indicated that some changes in psychosocial factors were mediators of the improved changes noticed in the targeted food hygiene behaviors.

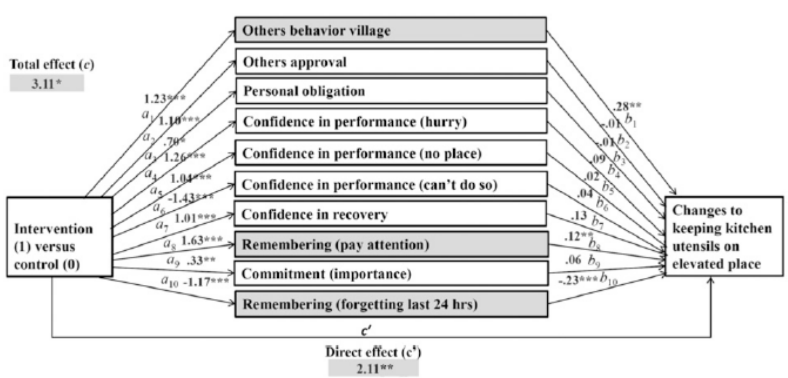

FIGURE 3. Multiple mediation: effects of intervention on changes to keeping kitchen utensils at a safe place with soap via changes in psychosocial factors (mediators).

For changes in handwashing practice, mediation analysis uncovered feelings, others' behavior in the household, remembering (pay attention), and remembering (forgetting last 24 hours) as significant mediators. This, in turn, confirms the effectiveness of the behavior change intervention elements targeting, first, feelings (BCT 8) by describing feelings about performing and consequences of handwashing without soap; second, others' behavior in the household (BCT 9) by encouraging that others already perform the behavior; and third, remembering (BCT 34) by using memory aids and environmental prompts. The remaining factors in the mediation analysis were included in the intervention, but had no significant influence on the behavior. In summary, the cues for action increased the ability of the child caregivers to wash their hands with soap. In addition, the intervention significantly increased their positive feelings (like) about handwashing with soap. It also increased the perception by caregivers that other household members also performed handwashing with soap, which in return increased the caregivers practice. This adds to the growing research indicating a need to incorporate psychosocial factors, in addition to contextual elements, for the success of handwashing with soap promotion interventions.[54,56,57]

For intervention effects on changes in washing kitchen utensils with soap, significant mediators were changes in others' behavior in the household, targeted by encouraging others that some are already performing the behavior (BCT 9), and changes in the difficulty of having enough soap to wash kitchen utensils ("demonstrate and model behavior", BCT 17), which targeted ability, for example, confidence in performance. This is again a confirmation of the effectiveness of the tested interventions. Other remaining factors included in the mediation were tackled by the intervention, but exerted no significant influence on the behavior. In summary, the intervention significantly increased the influence of others' behavior in the household among study participants. Furthermore, the intervention increased the participants' understanding on the importance of using soap when washing utensils. This enabled them to prioritize soap for utensil washing (i.e., became less difficult to have soap), and this subsequently increased the performance of the behavior.

The mediators that influenced changes to the behavior about keeping utensils in a safe place included others' behavior in the village, remembering (pay attention), and remembering (last 24 hours). This confirms the effectiveness of incorporating public commitment (BCT 10), memory aids, and environmental prompts (BCT 34) in the intervention. Other factors included in the model were influenced by the intervention, but were not found to be significant for the behavior change. In summary, the intervention significantly increased the influence of the behavior of others in the village and remembering to keep kitchen utensils in a safe place among study participants, which in turn increased the practice.

Finally, the intervention package in our study included multiple BCT's that were derived from evidence-based baseline data.[37] Previous health behavior change research suggests that multiple behavior change interventions could provoke coaction,[58] which in turn increases the effectiveness of the whole intervention package. However, recent studies from Bangladesh and Kenya focused on WASH, and nutrition behaviors showed no differences between single and multiple interventions.[59,60] Despite the increase in targeted behaviors, some interventions from our study changed specific psychosocial factors significantly which, however, had no impact in changing the behavior. These findings are helpful to refine the intervention package. The BCTs corresponding to the significant psychosocial factors that were not relevant in changing the targeted behaviors could be further reviewed in future research interventions.

In summary, findings from our research study revealed a significant increase in self-reported target behaviors and in behavioral proxies after the intervention, uncovered the underlying mechanisms of behavior change interventions on target behaviors, and showed which interventions, (e.g., BCT's from the RANAS catalogue) were most effective in changing the behaviors. This research is especially relevant for future projects to refine behavior change interventions in this particular population and to ensure time and resources target interventions with the best opportunity for success.

Practical implications. The study results provide a platform and an opportunity to further integrate food hygiene into WASH and nutrition programming. In addition, the identified handwashing with soap behavior factors could be used to promote handwashing in existing sanitation programs such as community-led total sanitation to maintain a sustained behavior change. As such, our evidence-based research study is important for policy makers and programming in a number of ways.

First, community volunteers from the intervention area can be identified to deliver the behavior-centered intervention successfully. This process could, therefore, be integrated with existing programs such as scaling up nutrition caregiver groups and village health committees. However, community health workers must be available to regularly backstop the services of community volunteers with their expertise. Thereafter, handwashing BCTs from the intervention, addressing feelings, others' behavior in the household, and remembering should be practically delivered to the caregivers in conjunction with facts about the link between the handwashing practice and onset of diarrheal diseases.

Second, BCTs for washing utensils with soap targeting others' behavior in the household and difficulty to get enough soap should be implemented. Thus, the effective use of the intervention may encourage households to realign priorities for soap, which is critical in such low-income settings. For continuity, key handwashing with soap messages initially introduced should be incorporated and reiterated during this process.

Third, the caregivers should be introduced to the concept of keeping utensils in a safe place that will focus on others' behavior in the village and remembering. Importantly, already delivered behaviors (i.e., handwashing with soap and washing utensils with soap) need to be integrated in the implementation of this behavior. In addition, to foster confidence in performance, the demonstration on how to construct their own handwashing facilities and dish racks should be repeated from time to time among the child caregivers.

The perception of how others behave (others' behavior) had a strong significance across all three behaviors. Thus, a strong emphasis on these normative elements through the intervention may be necessary to successfully promote the desired food hygiene behaviors. In addition, this has demonstrated the importance of using the concept of "Hygienic Family" to influence the behavior of all family members.

By refining the interventions using psychological theories (e.g., the RANAS model) and specific statistical analysis methods (e.g., mediation analysis), the study has shown the effectiveness of incorporating the significant behaviors in the promotion of complementary food hygiene practices in rural household settings.

Limitations. Self-reported health behaviors are prone to bias.[61] However, this was controlled by conducting spot checks on a number of variables (i.e., handwashing with soap, washing utensils with soap, and keeping utensils in a safe place) that were reported by the participants. Much as the government extension health workers HSAs were incorporated in the delivery of the intervention, their participation (i.e., supervising the volunteers) was affected by their high workload because they are responsible for all health-related activities at the community level. However, this was addressed by using field intervention supervisors. Nevertheless, this may have an implication on the long-term sustainability and scalability of the intervention because the hired field intervention supervisors would not be there when the research project comes to an end. As such, there is a need for a follow-up study to assess how the existing structures have continued with the interventions without external support. Although the sample size in this study was less than the ANOVA calculation required, we are confident that the significant differences in behaviors reported reflect the legitimate impact of the intervention. Nevertheless, further data collection would support validation. The use of mass media as a communication channel should be taken into consideration in promoting the key behaviors on a wider scale.

CONCLUSION

The research study in this article is the first to address food hygiene behaviors using the RANAS behavior change approach. The evidence-based interventions successfully changed handwashing, washing utensils with soap, and keeping utensils in a safe place among the intervention households. In addition, our research study uncovered underlying behavior change mechanisms by identifying specific psychosocial factors relevant in changing the behaviors. However, further research should test other potential mediators or moderators of behavior.

Thus, the intervention package used in our study can be recommended for promotion of the behavior change to handwashing with soap, washing of utensils with soap, and keeping utensils in a safe place in rural settings of Malawi.

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5.7 Key findings of the intervention trial

This chapter presents findings of the implemented food hygiene intervention measured using a a randomized cluster before and after trial with a control design. Structured observations and hand hygiene audits were used to measure the proportion of child caregivers performing all the targeted food hygiene and handwashing practices. While a questionnaire based on the RANAS model of behaviour change was used, via face to face interviews, to assess the psychosocial factors that influenced behaviour change among the study participants. This study applied these two data collection methods (i.e. observations and household face-to-face interviews), as observation data was necessary to confirm the key findings of the study that were measured through the RANAS model based self – reported household face-to-face interviews. It was essential to confirm the self – reported data since it has been previously reported that the child caregivers tend to have a high level of knowledge about WASH practices, with few translating this knowledge into practice (Pang et al., 2015). The type and presentation of questions can also have an influence on whether the respondent over – reports (Curtis et al., 1993). The Likert scale - RANAS model based questions previously applied in other research (Messick, 1989) to measure psychological constructs, were used in this study to improve the understanding of the questions by the study participants. The Likert scale-based questionnaire provided a range of possible answers (five options) for the study participants to choose their specific responses relevant to the questions rather than if the "yes" or "no" type of responses were used.

Study findings presented in this chapter have shown that it is possible to successfully mediate change in the behaviours surrounding food hygiene in rural household settings of Malawi. Despite extreme levels of poverty within the study population, statistical analysis (chi-square) revealed significant difference between the intervention and control groups between baseline and follow up surveys in all observed hygiene proxy factors, i.e. the presence of a handwashing facility (HWF), presence of soap and water at the HWF, presence of water and soap at the site where utensils were washed, and presence of a dish rack.

The ANOVA results showed a significant difference between the intervention and control groups at follow up in all the five targeted behaviours: handwashing with soap at key times, washing kitchen utensils with soap, keeping kitchen utensils in a safe place, reheating of leftover food, and feeding of children by the caregivers. However, the results for reheating of leftover food and feeding children by the caregivers also changed significantly among the control group. As such, these two behaviours did not seem to have been influenced by the intervention. Failure of the intervention to influence these two behaviours could be attributed to the fact that fuel wood for cooking food remains a scarce resource in the area. In addition, cooking or reheating food using biomass takes time and requires more effort. This has the potential to influence the child caregivers (who are mostly multi-tasking and have a busy schedule) to partially reheat the food or feed the child cold food. It is important that future programme implementors should emphasize encouraging households to prepare adequate food for a specific meal to eliminate the need for reheating left–over food. Importantly, such programmes should focus on food hygiene promotion activities that are participatory and practical in nature for the child caregivers to appreciate the need for adequate reheating of left-over food before consumption.

During end of project evaluation, the targeted children were ageing (from 6 months at recruitment to 48 months at project evaluation), hence they preferred self - feeding which normally starts between 15 to 36 months among infants (Carruth et al., 2004). Where possible, child caregivers did not feed their children who were able to self-feed, but rather took the opportunity to concentrate on other household activities. It would not be appropriate to persuade the child caregivers to continuing feeding their children when they are ageing, as self-feeding is an important component of the child development process. However, there is a need for the child caregivers to take the responsibility of ensuring that the children wash their hands with soap before they start self–feeding, and provide the child with a clean environment in which to eat, free from dust, dirt and animal faeces. Thus, future food hygiene behaviour change programmes should emphasize on the need for the child caregivers to provide hygienic spaces, and be teaching their children to practice handwashing with soap before eating.

Mediation results showed that several psychosocial factors differed significantly between the intervention and control groups on the three significant behaviours (i.e. handwashing with soap, washing utensils with soap, and keeping utensils on an elevated place). This is an indication that psychosocial factors play an important role in influencing behaviours associated with food hygiene at household level. Social norms (i.e. descriptive norms) influenced these three significant behaviours. As reported elsewhere (Cooper, 2019), working with child caregiver subgroups provided a mechanism for the promoted behaviours to be adopted and had the potential for diffusing and sustaining new norms and behaviours to larger groups, while door to door household visits conducted by the community coordinators reinforced the new norms among the child caregivers. Despite social norms being amongst the strongest factors of hygiene behaviours at household level, it has been noted that social and behaviour change (SBC) approaches to complementary food hygiene often overlook social norms, targeting individual attitudes and beliefs (or focusing solely on structural-level factors) without addressing community rules and shared beliefs (Dickin et al., 2020). Considering that social norms cut across various aspects in the community, it has been suggested that exploring and addressing social norms to improve complementary feeding might have the most leverage in areas such as exclusion of foods based on health-related beliefs; responsive feeding; food hygiene; gender norms and family roles (Dickin et al., 2020). Thus, to influence change in social norms, there is a need for formative research to understand context specific norms and their influence on various aspects of the community.

In this study, contextual factors such as having a handwashing facility with soap and a dish rack for safe storage of utensils supported performance of the promoted behaviours. This confirms the notion that performance of recommended hygiene behaviours (such as handwashing with soap) is more frequent in households that have access to facilities (Luby et al., 2009; Luby & Halder, 2008; Schmidt, Aunger, et al., 2009; Seimetz et al., 2016c). As previously reported (Luby et al., 2009), presence of WASH infrastructure is a manifestation of the intention to perform a behaviour rather than an independent determinant. Availability of WASH infrastructure (i.e. handwashing facility with soap) motivates behaviour performance, acts as a cue for action and enhances social norms (Contzen et al., 2015). Thus, it is important that future WASH programmes should continue promoting availability of WASH infrastructure while reinforcing the psychosocial behavioural factors.

The research results show that the evidence-based interventions successfully changed handwashing, washing utensils with soap, and keeping utensils in a safe place among the intervention households. In addition, our research findings uncovered underlying behaviour change mechanisms by identifying specific psychosocial factors relevant in changing the behaviours.

Chapter – 6

Conclusion and Recommendations

6.1 Rationale

Chapter 6 presents a summary of progress towards the overall aim and objectives of the study, with the key findings for each. It also highlights the limitations, overall conclusions and recommendations of the study, with future research considerations.

6.2 Overall aim and objectives of the study

An intervention to improve food hygiene behaviours was successfully developed, implemented and evaluated with relevant stakeholders and child caregivers in rural Malawi. Based on the objectives set out at the beginning of this study, the following was achieved:

1. Research and programming gaps addressing domestic food hygiene at household level in low and middle income countries (LMICs) were identified, and are presented in
2.
3.
4. **Chapter – 1** and
5.
6.

7. **Chapter 2** of this thesis. This included the review of existing research and literature to establish current knowledge and actions related to critical control points and recommended actions in preventing food borne illnesses at household level in low income settings of the world. Furthermore, WASH behaviour change theories/models suitable for a food hygiene behaviour change intervention trial were examined and critically assessed .

Through formative research (Chapter 3), this study identified and evaluated current food hygiene practices among child caregivers with children aged five years and below in rural households of Malawi. Using structured observations and microbial sample collection and analysis, the study specifically assessed food hygiene practices critical to the prevention of food borne diseases including diarrhoea among under five year old children in rural Malawi. It is important to note that structured observation as a method of data collection has been associated with influencing the study participants' behaviour due to the presence of the observer (Pedersen et al., 1986). To address this problem, the study participants were told that the purpose of the observations was to learn about daily care of their young children. In addition, the observations were conducted for six hours per household per day, as an extended duration has been associated with reduced reactivity (Cousens et al., 1996). In our study, observations were not conducted repeatedly per household due to resource (cost and time) constraints. Similar studies in the future should consider conducting the observations repeatedly since this has been proven to strengthen the validity and reliability of observations as a data collection method (Curtis et al., 1993). Such observation studies could also include more than one observer per session to allow all practices to be fully captured for inter-observer analysis. However, the context in which observations take place should be considered to ensure that conducting observations repeatedly with the presence of additional observers in a small space will not lead to a higher level of social desirability bias.

8. Formative research (Chapter 3) also investigated and interpreted the behavioural factors associated with the identified context specific food hygiene practices in the study area. For the first time, the RANAS model of behaviour change (Mosler & Contzen, 2016) was used to identify the psychosocial and contextual factors underlying identified food hygiene behaviours. This data in combination with the observed practices was essential for the subsequent development of the trial intervention.
9. Formative research informed the design of an intervention to improve food hygiene behaviours among child caregivers in rural Malawi which was then tested in a randomized before and after trial with a control (Chapter – **4**). The behaviour centred intervention was implemented through community based coordinators for nine months, applying behaviour change techniques (BCTs) identified through the RANAS model of behaviour change.
10. The trial was evaluated to determine the effectiveness of the implemented behaviour change interventions on food hygiene practices and behavioural factors among child caregivers. The study revealed the mechanisms and factors underpinning changes in food hygiene behaviours after implementation of the intervention. Thus, it ascertained that a behaviour change centred intervention was able to both directly and indirectly influence changes in contextual and psychosocial factors, leading to improvements in some targeted food hygiene behaviours. It should be mentioned that this trial evaluated psychosocial factors of food

hygiene behaviours using self – reported data which are prone to bias (Curtis et al., 1993). However, this was controlled by conducting observations on a number of variables (i.e. handwashing with soap, washing utensils with soap and keeping utensils on a safe place) that were reported by the participants. Direct observations of hygiene practices have been considered as the most valid and reliable method of measuring hygiene behaviours at household level (Biran et al., 2008; Cousens et al., 1996).

6.3 Summary of study findings

The study findings suggest that use of a theory driven behaviour change model is capable of promoting improvements in multiple food hygiene behaviours among child caregivers in rural Malawi. For the first time, the study results have shown that addressing psychosocial factors guided by the behaviour change techniques (BCTs) of the RANAS model (Mosler & Contzen, 2016) can bring about desired changes in food hygiene behaviours. However, these must be applied with consideration to appropriate contextual factors such as presence of WASH infrastructure (e.g. dish rack and handwashing facility) and related materials (e.g. soap and water), which play a significant role if desired behaviours are to be achieved and sustained.

After intervention implementation, significant improvements were identified in the following behaviours among the intervention group in comparison to both baseline and the control group: handwashing with soap at key times; washing kitchen utensils with soap; keeping kitchen utensils in a safe place. Reheating of leftover food and feeding children by the caregivers were not influenced by the intervention. Failure of the intervention to influence reheating of leftover food could be attributed to the fact that fuel wood for cooking food remains a scarce resource in the study area, and setting a fire for reheating and waiting for food to reach a high time temperature also places a significant time burden on caregivers, who in essence have prepared extra food to save time. In addition, by the time end line evaluation was being conducted, the targeted children were older, as such rather than being fed by the caregiver, they preferred self – feeding. This is an important aspect of child development, and was also an advantage to the child caregiver as it enabled them to concentrate on other household activities. With this in mind, intervention adaptation should be considered for these key behaviours to take into consideration these arising contextual factors. For example, future programme implementors should encourage households to prepare adequate food for a specific meal to eliminate the need for reheating leftover food, ensure safe feeding of younger children, and ensure older children wash their hands with soap before they start self-feeding.

The significant improvement in the targeted behaviours among the intervention participants can be attributed to several factors.

(1) The use of practical demonstrations to show how cross contamination occurs and the effectiveness of soap in removing dirt and bacteria motivated the participants to practice the desired behaviours (e.g. handwashing with soap at selected critical times).

(2) Cluster meetings provided a safe and supportive environment in which child caregivers could share their successes and failures. For example, those who had adopted the promoted behaviours explained to their colleagues during cluster meetings how they managed to perform the behaviours and this might have encouraged others to do the

same in their homes. Similarly, those who were struggling to make soap available could ask how others were managing, to gain insights and alternative ideas (Malolo et al., 2020).

(3) Use of cues for action such as bracelets and buntings reminded the household members to perform the targeted behaviours. However, it was observed that the bibs were not preferred by the children; they could not fit into them since they were ageing. Hence they were uncommonly used by the children during eating. Thus, it is important to test the appropriateness of an intervention if it fits with the local context.

(4) Practical demonstrations on how to construct handwashing facilities and dish racks with the use of locally available resources motivated the caregivers to construct and maintain such facilities in their homes. The presence of such facilities in combination with cues for action motivated the child caregivers and other household members to perform the related promoted behaviours, and increased the ease with which they could be performed as noted during observations.

(5) Household follow-ups have been reported to motivate the performance of targeted behaviours in a hygiene campaign (Christensen et al., 2015; Parvez et al., 2018). Thus, frequent household visits conducted by the community volunteers recruited in the project had an influence in the adoption of the targeted behaviours. However, it may not necessarily be required that the household visits should be very intensive to bring the required change.

The nine months promoted food hygiene intervention was rigorous. However, it may be adjusted to fit into existing community health and WASH programmes. The associated expenses highlighted in another paper (Panulo et al., 2021) may be adjusted to only focus on those items/activities that are needed to implement the intervention; leaving out the intervention development cost (including time) since the intervention has already been designed and developed by this research.

The literature review presented in

Chapter 2 has shown that Malawi has an enabling environment to support promotion of food hygiene behaviours at household level. For instance, food hygiene interventions can easily be integrated into existing the Community Led Total Sanitation (CLTS) programme which is being used nationally to promote WASH practices. Thus, Government extension workers (i.e. the Health Surveillance Assistants [HSA]) and existing community structures such as Village Health Committees (VHCs) and traditional leaders already involved in the CLTS programme should also promote food hygiene initiatives. Much as the HSAs were involved in the delivery of this trial, their participation (i.e. supervising the community volunteers) was affected by their high workload since they are responsible for all health-related activities at community level. For the purpose of this study, this was addressed by employing field intervention supervisors. Nevertheless, this may have an implication on the long-term sustainability and scalability of the intervention since the hired field intervention supervisors would not be there. As such similar interventions in the future should consider using existing community structures. Specifically, the HSAs should be used as supervisors to the VHC members who will deliver the intervention in the community households. With this arrangement, the HSAs will not be fully required to implement the project; thus giving them more time to concentrate on other duties.

It should be mentioned that the CLTS programme emphasizes latrine use and construction of a handwashing facility near the latrine; food hygiene and associated practices are not currently included. Similarly, national nutrition programmes such as the Scaling Up Nutrition (SUN) focus on nutrition specific activities (e.g. food supplementation) with little emphasis on nutrition sensitive initiatives such as food hygiene. It is important that this missed opportunity be addressed if adequate progress is to be made towards overall hygiene promotion at household level. Much focus should be particularly put on SUN as it uses caregiver group model.

This study was conducted in the rural district of Chikwawa in Southern Malawi. Thus it may not be generalizable to the whole of Malawi. The study findings may need to be verified if they are to be applied in the urban context. For instance, there is more storage of already prepared food including porridge as it is prepared ahead of time in the urban areas and the children may spend some of their time in the Early Childhood Development Centres (ECDCs) where they are provided with food. Further, there is less social capital in the urban areas (Hill et al., 2014; Melariri et al., 2019; Mwapasa, 2021). Nevertheless, the delivery approach (e.g. use of cluster meetings/mother groups and home visits) of the food hygiene intervention tested in this research has been proven to be successful in other parts of rural Malawi (other than Chikwawa) for maternal and child health (Fitzsimons et al., 2016; Manda-Taylor et al., 2017; Rosato et al., 2010; Zimba et al., 2012).

This research provides a good platform for understanding the contextual and psychosocial factors related to complementary food hygiene practices for the design of an effective food hygiene intervention in rural Malawi. Further, the evidence-based intervention successfully changed food hygiene behaviours among the intervention households. This research study uncovered underlying behaviour change mechanisms by identifying specific psychosocial factors relevant in changing the behaviours.

6.4 Overall conclusion

This thesis presents research that has demonstrated it is possible to improve food hygiene behaviours in rural settings of low income countries like Malawi. There are a number of factors that contributed to the success of the tested intervention such as use of community coordinators to deliver the intervention and use of health promotion (i.e. practical demonstrations, cues for action and role models) rather than the traditional one way communication health education approach. In addition, the project staff and community volunteers that were involved in the delivery of the intervention were well trained and there was adequate supervision at all levels of the intervention implementation.

The study has indicated that behaviour change theory driven innovative approaches are required if we are to improve the deep rooted habits associated with household food hygiene. For instance use of specific behaviour change techniques to shift social norms among the child caregivers needs to be incorporated in a food hygiene campaign. All food hygiene behaviours promoted in this research have the potential to improve child health through reduced diarrhoea disease (Morse et al., 2020) and malnutrition. However, it should be mentioned that there is a need to assess the long term sustainability and scalability of the intervention in different contexts which may be hastened by incorporating food hygiene interventions into existing community health programmes. Thus, public health planners and implementers (including WASH and nutrition) should be targeted to ensure that food hygiene interventions are part of the priority areas in their programming.

This research study confirms that:

- Identifying and targeting contextual factors (such as homogeneity in diet, availability of caregivers including men at household, free movement of domestic animals and income level of the households) is critical in the promotion of food hygiene interventions in rural household settings.
- For our study, the contextual (e.g. availability of WASH infrastructure) and the following psychosocial factors were crucial in changing targeted behaviours: personal perceived risks (e.g. if they did not wash hands with soap), descriptive norms (i.e. behaviour of others e.g. relatives), personal confidence to perform the behaviours and self – regulation attributes (e.g. cues for action) were important to facilitate food hygiene behaviour change.

- Food hygiene research targeting the household setting has been rarely studied in low income countries including Malawi. Relatedly, this study is one of the few that have explicitly evaluated perceived changes in social norms about food hygiene behaviours.
- The three targeted food hygiene behaviours (handwashing with soap at the identified critical times; washing of utensils with soap before use; and safe storage of utensils and food) are critical in the promotion of household food hygiene interventions in rural household setting.
- Use of theory driven food hygiene interventions has the potential to bring in significant behavioural change on food hygiene related behaviours. To our knowledge, this study is the first to successfully apply the RANAS model of behaviour change to influence food hygiene behaviours at household setting.
- Use of already existing community structures (e.g. community health volunteers and Government community health workers – i.e. HSAs) is vital if significant progress is to be achieved in promoting food hygiene behaviours in rural household settings.
- To bring effective change on food hygiene behaviours among the child caregivers, hygiene promotion strategies should be participatory and incorporate interesting and attractive behaviour change promotion activities.
- This research has shown that use of multiple communication channels (e.g. household visits, cluster meetings and open days) in the delivery of the intervention has an influence on improving food hygiene behaviours among the child caregivers in rural household settings.

- Malawi has an enabling environment to support implementation of food hygiene interventions at rural household setting. For instance food hygiene promotion activities can be integrated into existing hygiene and nutrition promotion programmes such as the Scaling Up Nutrition (SUN).

6.5 Recommendation

- Designing of food hygiene behaviour change interventions should be population tailored. Thus, formative research should be conducted at the onset of such interventions to understand the key behaviours, including their behavioural factors, if successful results are to be realized in a food hygiene behaviour change intervention. Formative research may also be considered for ongoing WASH and food hygiene programmes to assess progress and make alterations where necessary.
- Implementation of food hygiene promotion initiatives should be guided by proven behaviour change theories. This study has demonstrated the effectiveness of applying RANAS model of behaviour change in food hygiene interventions at rural household level.
- Results have shown that implementation of a behaviour centred intervention which targets multiple food hygiene behaviours is possible. Nevertheless, future programme designers should ensure that a holistic approach is applied so that all the behaviours are promoted equally as they are significant to the safety of a child’s food. For instance, thorough reheating of left-over food may be obsolete if serving utensils are not washed properly with soap. Similarly, washing the utensils with soap may not help if they are kept in a place easily reached by domestic animals or pests. Importantly, all these behaviours

may fail to prevent disease transmission if children eat their food with dirty, potentially contaminated hands.

- Most of the targeted behaviours at household setting were performed by the mother of the child with support from other household members such as older children, aunts or grandmothers. Although the intervention aimed to target all household members there was a significant focus on the mother as the main caregiver. However, future interventions should target all household members rather than focusing on one individual, to support household adoption of behaviours and ensure sustained change.
- This study has shown the effectiveness of addressing social norms as an important component for improving food hygiene practices in addition to the contextual factors. Thus, behaviour change interventions in future should consider targeting these attributes. In addition, cues for action, demonstrations/practical sessions, WASH infrastructure, household visits and cluster meetings should be considered in similar interventions since they have proven to be effective communication channels in bringing positive change related to food hygiene interventions.
- To ensure that issues of household food hygiene are supported at all levels, programme implementers should identify and integrate behaviour change techniques that effectively brought change in the targeted behaviours in this study. Such techniques should be incorporated in existing community Nutrition and WASH programmes (e.g. for Malawi it could be integrated in the Scaling Up Nutrition (SUN)). This study provides insights on appropriate actions required to address barriers related to food hygiene practices at household domain.

6.6 Areas for further research

- The tested intervention in this study was implemented in a small rural area in Malawi and was supported by the research project intervention staff and existing community health structures. Thus, more effort is needed to evaluate and assess the sustainability of WASH, food hygiene and behaviour change interventions in a wider population, including urban settings, for longer periods. The evaluation should also assess the feasibility of implementing such interventions without involvement of temporary, hired project staff, but rather using local human resource (e.g. community extension workers and community committees).
- Further research is needed to assess the link between specific food hygiene behaviours and its impact on the nutritional status of young children. This is critical in informing future food hygiene interventions and promotion of child health.
- More research work is needed to provide details about the link between enteric pathogen pathways and associated health outcomes. This will guide in the design of context specific behaviour change interventions appropriate for rural household settings.
- Considering that this research has identified specific perceived risk, descriptive norms, confidence in performance and self-regulation as major factors of the targeted key food hygiene behaviours, it is important that more evidence is provided on the effectiveness of these attributes on child health outcomes related to food hygiene behaviours.
- Further research is needed to test other potential mediators or moderators of food hygiene behaviour.

- Further research is needed to develop approaches that require minimal contact time during delivery of the intervention yet still remain effective. This will help to address the challenges associated with resource constraints in the implementation of WASH and food hygiene interventions at household level.
- Descriptive norms were found to facilitate change in the three significant behaviours (i.e. washing utensils with soap, keeping utensils safely and handwashing with soap). Thus, they have been strongly identified as potential factors for the adoption of improved food hygiene behaviours among the child caregivers in rural household settings. Nevertheless, more research is needed to confirm this assertion.

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Appendix 1: Structured observation form

Structured Observation Checklist (Household)

Informed Consent Form

Good morning! My name is ______________________. I am working for ……, a non-profit, non-governmental organization, based in …… Currently, we are conducting the study on **"……….."** in x districts of ……. (……..) for WASHTED and SHARE.

The main objective of this study is to learn on how you care for child during the day. In order to do so, we would like to observe your daily activities for about 6 hours. We will observe in those houses of mother (or primary care takers of children if mother is not available) who have child aged 18-59 months. Your participation is voluntary. You can stop at any point during the observation.

We would be grateful if you allow us for the observation since this observation will be extremely important and will contribute to our study. During the observation you do not need to do any additional thing just continue your normal/routine day practices/work.

Do you have any questions? Yes No

Do I have your consent to begin the observation now? Yes No

Observers visits record			
Date of interview			
Household ID			
Name of observer	…………………………	………………………………	………………………………

Observation result *(Instruction; please mention reason behind refusing)*	Observation completed……………………………....1 Not met concerned person for observation……….2 Said to observe next time…………………….........3 Nobody met at home …………………..................4 Observation Incomplete……………………….......5 Refused for observation.......................................6 Other (specify)..

Note for observer: *Please make the purpose of your visit anonymous. Don't use structured observation checklist in-front of mother. Only use notebook to make notes and record observed behaviours during structured observation. Don't give any signal/clue that you are observing mother's hygiene key behaviours. You will only mention your purpose of visit is to know the 'daily routine of mothers and to know the diarrhoea status of their children aged between 18-59 months in last two week'. Make sure that you are observing mother's hygiene behaviour in-between 6-12 noon and mark in the checklist accordingly. Only observe one household per day.*

Structured observation starts at 6am or 1pm:
Note for observer*: don't ask any question to mother. Only observe mother or primary care takers of children if mother is not available) behaviours but not the behaviours of other family members in house. If mother (or primary care taker) is not available at home, go to next participating household. If mother (or primary care taker) is available at home, briefly talk about her daily routine or any other local functions/rituals but don't talk too much. Observe behaviours as reflected in the structured observation checklist below. Only circle the correct answer soonest after you complete the observation in respective house.*

Section 1: Household/Cluster Identification

Q. N	Question	Response	Code	Instruction
	District name	☐☐ __________		
	TA name	☐☐		

		1. Masache 2. Ngowe 3. Ngabu 4. Maseya		
	Village name	TA Masache: 1. Thudzu 2. Lolle 3. Mtayamanja 4. Lombe 5. Masache 6. Mtuwa 7. Anthuachino 8. Jackson 9. Konzere 10. Jackson TA Ngowe 1. Khukhumba 2. Mwananjobvu 3. Langwani 4. Chiphuphu 5. Khungubwe TA Ngabu 1. Malikopo 2. Nyaika 3. Jese 4. Nkhwangwa 5. Julius TA Maseya 1. Frank 2. M’bande 3. Kaphiri 4. Paulosi 5. Tome 6. Nenenji 7. Makhwatha 8. Mwasiya 9. Bandiwiki 10. Bereu		

Observe the behavioural practices of mother or primary caretakers of children having children from 18-59 months

Now I am going to start my observational works.

Food hygiene			
Breakfast			
Q.N	**Questions**	**Response**	**Code**
1.	What type of food has been eaten	Porridge	1
		Potatoes only	2
		Potatoes with tea	3
		Pumpkin only	4
		Pumpkin with tea	5
		Bread/scorn with tea	6
		Other (specify)……………………………	99
2.	Who prepared the food	Mother	1
		Father	2
		Sibling	3
		Grandfather	4
		Grandmother	5
		Others (Specify)	99
3.	Observe steps followed when preparing food for the child ***(write the steps in order)***		
4.	Were hands washed before food preparation	yes	1
		No	0
5.	If yes, what was used to wash hands before food preparation	Water only	1
		Water and soap	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
6.	Was the food freshly prepared	Yes	1
		No	0

7.	If no, was the food stored	Yes	1
		No	0
8.	How was the food stored	Covered pot	1
		Covered plate	2
		Uncovered pot	3
		Uncovered plate	4
		Others (Specify)	99
9.	When was it prepared	Within one hour	1
		Between 2 – 4 hours ago	2
		Between 4 – 6 hours ago	3
		Over 6 hours ago	4
		Don't know	98
10.	Was it reheated before consumption	Yes	1
		No	0
11.	If yes, was the food reheated to boiling point	Yes	1
		No	0
12.	Who fed the target child	Mother	1
		Father	2
		Self - feeding	3
		Sibling	4
		Grandmother	5
		Grandfather	6
		Others (specify)	99
13.	What was used to feed the targeted child?	Spoon	1
		Hand	2
		cup	3
		Plate	4
		Both spoon and hands	5
		Others (specify)	99
14.	Were hands washed before eating/feeding	Yes	1
		No	0
15.	If yes, what was used to wash hands before eating/feeding	Water only	1
		Water and soap	2

		Water and ash	3
		Water and flour	4
		Others (specify)	99
16.	Where did eating took place	On the veranda	1
		Inside house	2
		In the kitchen	3
		In the household yard	4
		Others (specify)	99
17.	What utensils were used		
18.	Were the utensils washed before use	Yes	1
		No	0
19.	If yes, what was used to wash the utensils	Water only	
		Water and soap	1
		Water and sand	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
20.	Were the utensils washed immediately after use	Yes	1
		No	0
21.	Were the utensils accessed by animals in between use	Yes	1
		No	0
22.	If yes, for how many times were the utensils accessed by the animals	once	1
		Two times	2
		Three times	3
		Four times	4
		5 times	5
		More than 5 times	6
23.	Where were the clean utensils stored when inside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4

		Others (specify)	99
24.	Where were the clean utensils stored when outside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
25.	Where were the dirty utensils stored when inside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
26.	Where were the dirty utensils stored when outside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
27.	Is any cooked leftover/stored food at home/Kitchen observed? *(Note: Make sure that you will observe all the potential areas of food storage.)*	Yes	1
		No	0
28.	What type of left-over food has been stored	Nsima	1
		Porridge	2
		Relish	3
		Potatoes	4
		Cassava	5
		Sorghum	6
		millet	7
		Rice	8
		Others (specify)	99
29.	Is leftover/stored food/cooked food kept covered with covering lid?	Yes	1
		No	0

	(Note: If all foods were covered then only mark as Yes. If some covered and some not then mark No)		
Lunch			
Q.N	**Questions**	**Response**	**Code**
30.	What type of food has been eaten	Porridge	1
		Nsima with ndiwo	2
		Rice with ndiwo	3
		Potatoes only	4
		Potatoes with tea	5
		Pumpkin only	6
		Pumpkin with tea	7
		Bread/scorn with tea	8
		Other (specify)……………………….	99
31.	Who prepared the food	Mother	1
		Father	2
		Sibling	3
		Grandfather	4
		Grandmother	5
		Others (Specify)	99
32.	Observe steps followed when preparing food for the child ***(write the steps in order)***		
33.	Were hands washed before food preparation	yes	1
		No	0
34.	If yes, what was used to wash hands before food preparation	Water only	1
		Water and soap	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
35.	Was the food freshly prepared	Yes	1
		No	0
36.	If no, was the food stored	Yes	1
		No	0

37.	How was the food stored	Covered pot	1
		Covered plate	2
		Uncovered pot	3
		Uncovered plate	4
		Others (Specify)	99
38.	When was it prepared	Within one hour	1
		Between 2 – 4 hours ago	2
		Between 4 – 6 hours ago	3
		Over 6 hours ago	4
		Don’t know	98
39.	Was it reheated before consumption	Yes	1
		No	0
40.	If yes, was the food reheated to boiling point	Yes	1
		No	0
41.	Who fed the target child	Mother	1
		Father	2
		Self - feeding	3
		Sibling	4
		Grandmother	5
		Grandfather	6
		Others (specify)	99
42.	Were hands washed before eating/feeding	Yes	1
		No	0
43.	If yes, what was used to wash hands before eating/feeding	Water only	1
		Water and soap	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
44.	Where did eating took place	On the veranda	1
		Inside house	2
		In the kitchen	3
		In the household yard	4
		Others (specify)	99
45.	What utensils were used		

46.	Were the utensils washed before use	Yes	1
		No	0
47.	If yes, what was used to wash the utensils	Water only	1
		Water and soap	2
		Water and sand	3
		Water and ash	4
		Water and flour	5
		Others (specify)	99
48.	Were the utensils washed immediately after use	Yes	1
		No	0
49.	Were the utensils accessed by animals in between use	Yes	1
		No	0
50.	If yes, for how many times were the utensils accessed by the animals	once	1
		Two times	2
		Three times	3
		Four times	4
		5 times	5
		More than 5 times	6
51.	Where were the clean utensils stored when inside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
52.	Where were the clean utensils stored when outside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
53.	Where were the dirty utensils stored when inside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2
		On a raised place (on a rack)	3

		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
54.	Where were the dirty utensils stored when outside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
Dinner			
Q.N	**Questions**	**Response**	**Code**
55.	What type of food has been eaten	Porridge	1
		Nsima with ndiwo	2
		Rice with ndiwo	3
		Potatoes only	4
		Potatoes with tea	5
		Pumpkin only	6
		Pumpkin with tea	7
		Bread/scorn with tea	8
		Other (specify)……………………….	99
56.	Who prepared the food	Mother	1
		Father	2
		Sibling	3
		Grandfather	4
		Grandmother	5
		Others (Specify)	99
57.	Observe steps followed when preparing food for the child ***(write the steps in order)***		
58.	Were hands washed before food preparation	yes	1
		No	0
59.	If yes, what was used to wash hands before food preparation	Water only	1
		Water and soap	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99

60.	Was the food freshly prepared	Yes	1
		No	0
61.	If no, was the food stored	Yes	1
		No	0
62.	How was the food stored	Covered pot	1
		Covered plate	2
		Uncovered pot	3
		Uncovered plate	4
		Others (Specify)	99
63.	When was it prepared	Within one hour	1
		Between 2 – 4 hours ago	2
		Between 4 – 6 hours ago	3
		Over 6 hours ago	4
		Don’t know	98
64.	Was it reheated before consumption	Yes	1
		No	0
65.	If yes, was the food reheated to boiling point	Yes	1
		No	0
66.	Who fed the target child	Mother	1
		Father	2
		Self - feeding	3
		Sibling	4
		Grandmother	5
		Grandfather	6
		Others (specify)	99
67.	Were hands washed before eating/feeding	Yes	1
		No	0
68.	If yes, what was used to wash hands before eating/feeding	Water only	1
		Water and soap	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
69.	Where did eating took place	On the veranda	1
		Inside house	2
		In the kitchen	3
		In the household yard	4

		Others (specify)	99
70.	What utensils were used		
71.	Were the utensils washed before use	Yes	1
		No	0
72.	If yes, what was used to wash the utensils	Water only	
73.		Water and soap	1
		Water and sand	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
74.	Were the utensils washed immediately after use	Yes	1
		No	0
75.	Were the utensils accessed by animals in between use	Yes	1
		No	0
76.	If yes, for how many times were the utensils accessed by the animals	once	1
		Two times	2
		Three times	3
		Four times	4
		5 times	5
		More than 5 times	6
77.	Where were the clean utensils stored when inside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
78.	Where were the clean utensils stored when outside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
79.	Where were the dirty utensils stored when inside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2

		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
80.	Where were the dirty utensils stored when outside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
Snacks – *possibility of repeating in ODK*			
Q.N	**Questions**	**Response**	**Code**
81.	What type of snack has been eaten	Sweet	1
		Fruit	2
		kamba	3
		Scone	4
		Biscuit	5
		sugarcane	6
		Mkute	7
		Other (specify)……………	99
82.	Who prepared the snack	Mother	1
		Father	2
		Sibling	3
		Grandfather	4
		Grandmother	5
		Not prepared	
		Others (Specify)	99
83.	Were hands washed before snack preparation	yes	1
		No	0
84.	If yes, what was used to wash hands before snack preparation	Water only	1
		Water and soap	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
85.	Was the snack freshly prepared	Yes	1
		No	0

86.	If no, was the snack stored	Yes	1
		No	0
87.	How was the snack stored	Covered pot	1
		Covered plate	2
		Uncovered pot	3
		Uncovered plate	4
		Others (Specify)	99
88.	When was it prepared	Within one hour	1
		Between 2 – 4 hours ago	2
		Between 4 – 6 hours ago	3
		Over 6 hours ago	4
		Don't know	98
89.	Was it reheated before consumption	Yes	1
		No	0
		N/A	97
90.	If yes, was the food reheated to boiling point	Yes	1
		No	0
		N/A	97
91.	Who fed the target child	Mother	1
		Father	2
		Self - feeding	3
		Sibling	4
		Grandmother	5
		Grandfather	6
		Others (specify)	99
92.	Were hands washed before eating/feeding the snack	Yes	1
		No	0
93.	If yes, what was used to wash hands before eating/feeding	Water only	1
		Water and soap	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
94.	Where did eating took place	On the veranda	1
		Inside house	2
		In the kitchen	3
		In the household yard	4

		Others (specify)	99
95.	What utensils were used		If no utensil was used, Skip utensils related questions below
96.	Were the utensils washed before use	Yes	1
		No	0
97.	If yes, what was used to wash the utensils	Water only	
		Water and soap	1
		Water and sand	2
		Water and ash	3
		Water and flour	4
		Others (specify)	99
98.	Were the utensils washed immediately after use	Yes	1
		No	0
99.	Were the utensils accessed by animals in between use	Yes	1
		No	0
100.	If yes, for how many times were the utensils accessed by the animals	once	1
		Two times	2
		Three times	3
		Four times	4
		5 times	5
		More than 5 times	6
101.	Where were the clean utensils stored when inside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
102.	Where were the clean utensils stored when outside the house	On the floor	1
		In bucket placed on the floor	2
		On a raised place (on a rack)	3

		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
103.	Where were the dirty utensils stored when inside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
104.	Where were the dirty utensils stored when outside the house	On the ground within HH yard	1
		In bucket placed on the ground within HH yard	2
		On a raised place (on a rack)	3
		In bucket placed on a raised place (on a rack)	4
		Others (specify)	99
Faeces management			
105.	Does the household have a toilet	Yes	1
		No	0
106.	What is the type of the toilet	Unimproved Traditional latrine	1
		Improved traditional latrine	2
		Ventilated improved latrine	3
		Ecosan toilet	4
		Flash toilet	5
		Others (specify)	99
107.	Is there a drop-hole cover	yes	1
		No	0
108.	Is the drop hole cover fitted on the latrine hole	Yes	1
		No	0
109.	Assess condition of toilet by observing the following: *(Instruction: "Clean" means that the floor, drop hole and walls of the toilet are visibly clean)*	Yes	1
		No	0
110.	Who used the toilet during period of observation	Father	1
		Mother	2
		Target child	3

		Sibling	4
		Grand father	5
		Grand mother	6
		None	7
		Others (specify)	99
111.	Is human faeces' observed in the household premises?	Yes	1
		No	0
Child defecation – *Possibility of repeating in ODK*			
112.	Did child defecate during observation time?	Yes	1
		No	0
113.	Where did child target child defecate?	In open place (anywhere)	1
		Potties	2
		Nappies/diapers	3
		Clothes	4
		Others (Specify)…………………	99
114.	How was the child's faeces disposed?	Picked up and disposed in toilet	1
		Picked up and disposed in dumping side	2
		Left as it is	3
		Covered with soil	4
		Throw anywhere	5
		Wash in bucket	6
		Others (specify)……………………………….	99
115.	If disposed in toilet, what was used to carry the faeces	Hoe	1
		Shovel	2
		Leaves	3
		Piece of metal	4
		Piece of paper	5
		Bare hands	6
		Others (specify)	99
116.	If faeces were removed from where the child defecated and disposed somewhere, are some faeces still remain on the disposal place?	yes	1
		No	0
117.		Washed immediately when soiled	1

	How were soiled nappies/clothes treated	Packed in bucket to be washed later	2
		Packed on another place e.g. roof to be washed later	3
		Clothes/nappies not soiled	4
		Others specify	99
Animal faeces			
118.	Are there domestic animals at the household	Yes	1
		No	0
119.	What domestic animals are present	Poultry	1
		Pig	2
		Cattle	3
		Goat	4
		Sheep	5
		Dog	6
		Cat	7
		Others	99
120.	Are animal faeces present inside the house	Yes	1
		No	0
121.	Are animal faeces present outside the house	Yes	1
		No	0
122.	The droppings are from which animals?		
123.	Has there been an attempt to remove the animal faeces if present	Yes	1
		No	0
Handwashing – *Possibility of repeating in ODK*			
124.	Is there a specific hand washing station/area?	Yes	1
		No	0
125.	How many specific handwashing facilities were there		
126.	What is the location of the handwashing facility(s)	Inside or near the latrine	1
		Under the dish rack	2
		near the cooking place/fire	3
		Elsewhere inside the house	4
		Outside the house near the door	5
		Elsewhere in the compound	6
		Others (Specify)	99

127.	Are soap and water available in the hand washing station/area?	Only Soap	1
		Only Water	2
		Both Soap and Water available	3
		Both Soap and Water unavailable	4
		Ash and water	5
		Other(Specify)…………………………	99
128.	What type of soap is it?	Liquid soap	1
		Bar soap	2
		Powdered soap	3
		Ash	4
		Flour	5
		Others (Specify)	99
Household water management			
1. Drinking water			
129.	What is the main source of drinking water used by the household?	Piped water in residence	1
		Piped water to tap in yard, plot	2
		Borehole	3
		Protected spring	4
		Surface water	5
		Water vendor	6
		Other (specify)…………………..	99
130.	How is drinking water stored within the household?	Covered Barrel	1
		Open barrel	2
		Covered bucket	3
		Open Bucket	4
		Covered Mtsuko	5
		Open mtsuko	6
		Other (Specify)………………..	99
131.	What is the condition of the stored drinking water? *(Clean means absence of clay, mud, turbidity in water, things like dust, animal hair, insects and any visible residue, colour objects in or on the surface of the water)*	Visibly Clean	1
		Visibly Dirty	0
132.	What is used to wash the drinking water storage container	Water only	1
		Water and soap	2
		Water and mud	3

		Water and ash	4
		Others (specify)	99
133.	Where is drinking water storage container placed within the household	Inside the house on a raised place	1
		Inside the house on the floor	2
		Outside the house on a raised place	3
		Outside the house on the ground	4
		Others (specify)	99
134.	Are drinking water containers/pots properly covered with covering lid? *(Properly covered means complete covering of the container)*	Yes	1
		No	0
135.	Can drinking water be accessed by animals	Yes	1
		No	0
136.	Was drinking water accessed by animals during observation period	Yes	1
		No	0
137.	If yes, for how many times was water accessed by the animals	once	1
		Two times	2
		Three times	3
		Four times	4
		5 times	5
		More than 5 times	6
138.	Which animals accessed the water	Poultry	1
		Pig	2
		Goat	3
		Cow	4
		Dog	5
		Cat	6
		Others specify	99
139.	How do they get/draw drinking water from the storage equipment		
2. Water for other domestic purposes (e.g. washing utensils, cooking)			
140.	What is the main source of water for other domestic purposes at the household?	Piped water in residence	1
		Piped water to tap in yard, plot	2
		Borehole	3
		Protected spring	4
		Surface water	5
		Water vendor	6

		Other (specify)…………………..	99
141.	How is water for other domestic purposes stored within the household?	Covered Barrel	1
		Open barrel	2
		Covered bucket	3
		Open Bucket	4
		Covered Mtsuko	5
		Open mtsuko	6
		Other (Specify)………………..	99
142.	What is the condition of the stored water for other domestic purposes? (*Clean means absence of clay, mud, turbidity in water, things like dust, animal hair, insects and any visible residue, colour objects in or on the surface of the water)*	Visibly Clean	1
		Visibly Dirty	0
143.	What is used to containers for storing water for other domestic purposes	Water only	1
		Water and soap	2
		Water and mud	3
		Water and ash	4
		Others (specify)	99
144.	Where are containers for storing water for other domestic purposes placed	Inside the house on a raised place	1
		Inside the house on the floor	2
		Outside the house on a raised place	3
		Outside the house on the ground	4
		Others (specify)	99
145.	Are water containers for other domestic purposes properly covered with covering lid? *(Properly covered means complete covering of the container)*	Yes	1
		No	0
146.	Can water for other domestic purposes accessed by animals	Yes	1
		No	0
147.	Was water for other domestic purposes accessed by animals during observation period	Yes	1
		No	0
148.	If yes, for how many times was water accessed by the animals	once	1
		Two times	2
		Three times	3
		Four times	4

		5 times	5
		More than 5 times	6
149.	Which animals accessed the water	Poultry	1
		Pig	2
		Goat	3
		Cow	4
		Dog	5
		Cat	6
		Others specify	99
150.	How do they get/draw the water for other domestic purposes from the storage equipment		
Child mouthing *(any object other than food being put in child mouth) – Possibility of repeating in ODK*			
151.	Is the child putting any object in his/her mouth?	Yes	1
		No	0
152.	If yes, What is being put in child mouth		
153.	For how long has it been in the child mouth		
154.	Was the object visibly dirty	Yes	1
		No	0
155.	Were child's hands visibly dirty	Yes	1
		No	0
156.	What was the reaction of the mother	Stopped the child	1
		Did nothing	2
		Removed the child	3
		Others (specify)	99
Other issues			
157.	Observe if the household has a raised place for storage of utensils inside the house?	Yes	1
		No	0
158.	Have you observed if the food hygiene bantings are hanged anywhere?	Yes	1
		No	0
159.	If yes where exactly are they hanged?	Window	1
		Door	2
		Sitting room	3

		Kitchen	4
		Veranda	5
		Others (Specify)	99
160.	Observe if the SHARE calendar is present at the household	Yes	1
		No	0
161.	Is anyone at the household wearing a handwashing with soap bracelet?	Yes	1
		No	0
162.	If yes, who is wearing the bracelet	Mother	1
		Father	2
		Grandmother	3
		Grandfather	4
		Sibling	5
		Others (Specify)	99

Please write down your observation note based on your observation (example: nappy not immediately washed after changed, mother might re-heat few foods, few not, mother might cleans few serving utensils few not, mother might have multiple exposure during feeding etc):

.

Thank you so much for your valuable time

Appendix 2: Hand hygiene audit observation form

share
Sanitation and Hygiene Applied Research for Equity

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Centre for Water, Sanitation, Health & Appropriate Technology Development

Hand Hygiene Observation Form

Date : **HH ID :** **District :**

TA : **Village :** **Observer Name :**

Op.	**Person**	**Event**	**HH Action**	**Handwashing facility**	**HWF location**	**Comments**
	☐ Mother ☐ Sibling ☐ Father ☐ G/parent ☐ Child ☐ Other Specify:	☐ child feeding ☐ before eating ☐ Food preparation ☐ changing nappy ☐ after latrine use ☐ Touch dirty things: Specify: ☐ Other Specify:	☐ water only ☐ water with soap ☐ water with ash ☐ water with sand ☐ water with flour ☐ No action	☐ Tippy tap ☐ Jug and basin ☐ bucket without tap ☐ bucket with tap ☐ cup only ☐ Deep in basin/bucket ☐ Other Specify:	☐ outside toilet ☐ Under dish rack ☐ in HH yard ☐ Inside the house ☐ Other Specify:	
Op.	**Person**	**Event**	**HH Action**	**Handwashing facility**	**HWF location**	**Comments**
	☐ Mother ☐ Sibling ☐ Father ☐ G/parent ☐ Child ☐ Other Specify:	☐ child feeding ☐ before eating ☐ Food preparation ☐ changing nappy ☐ after latrine use ☐ Touch dirty things: Specify: ☐ Other Specify:	☐ water only ☐ water with soap ☐ water with ash ☐ water with sand ☐ water with flour ☐ No action	☐ Tippy tap ☐ Jug and basin ☐ bucket without tap ☐ bucket with tap ☐ cup only ☐ Deep in basin/bucket ☐ Other Specify:	☐ outside toilet ☐ Under dish rack ☐ in HH yard ☐ Inside the house ☐ Other Specify:	

Appendix 3: Sample of Household questionnaire based on the RANAS model

Appendix 3A: Questionnaire based on the RANAS model for handwashing with soap behaviour

Behaviour factors	**Selected Items**
Risk Factors	
Vulnerability	In general, how high do you think is the risk that you get dirrhoea?
Severity	Imagine that you contracted dirrhoea how severe would be the impact on your life in general?
Health Knowledge	Can you tell me what causes dirrhoea? Could you please tell me for each following aspects whether it is a cause or not? E.g. Water contaminated by bacteria.
Attitudinal Factors	
Belief effort	How effortful do you think is washing hands with soap and water?
Belief time consuming	How time consuming do you think it is to always wash hands with soap and water?
Belief expensive	How expensive is it for you to always wash hands with soap and water?
Belief distance (far away)	Do you think that the hand washing facility is far away from your usual area of activity?
Belief certain for prevention	How certain are you that always washing hands with soap and water prevents you and your family from getting dirrhoea?
Feelings	How much do you like always washing hands with soap and water?
Normative Factors	
Others' behaviour household	How many people of your household always wash hands with soap and water?
Others' behaviour village	How many people of your village always wash hands with soap and water?
Others' approval	People who are important to you like your family members, friends, the chief of the village, NGO workers or Pastor, how much they approve that you always wash hands with soap and water?
Personal obligation	How strong do you feel a personal obligation to yourself to wash hands with soap and water?
Ability Factors	
Confidence in performance	How sure are you that you can wash hands with soap and water?
Difficult water	How difficult is to get as much water as you need to always wash hands with soap and water?
Difficult soap	How difficult is to get much soap as you need to always wash hands with soap and water?
Difficult time	How difficult is it have enough time to always wash hands with soap and water

Barriers distance	How confident are you that you can wash hands with soap and water, even if you have to walk some distance to reach the next hand washing facility?
Self-Regulation Factors	
Coping plan	Do you have a plan what to do so that you always have soap for hand washing? Please specify.
Remembering (pay attention)	How much do you pay attention to always have enough soap at home to wash hands with soap and water?
Remembering (forgetting last 24h)	When you think about the last 24 hours: How often did it happen that you forgot to wash your hands with soap and water?
Commitment (important)	How important is it for you to wash hands with soap and water?
Additional factor	How often do you discuss with others about handwashing with soap at critical times
Self-reported Behaviour	
Hand washing before eating main meals (e.g. lunch)	Before you feed your child main meals (e.g. lunch), how often do you wash your hands with soap and water? Before your child takes main meals (e.g. lunch), how often does he/she wash hands with soap and water? *(asked in case of child self-feeding)*
Hand washing after using the toilet	After you defecate, how often do you wash your hands with soap and water?
Hand washing before food preparation	Before you prepare food, how often do you wash your hands with soap and water?
Hand washing before eating snacks	Before you feed your child snacks, how often do you wash your hands with soap and water? Before your child eat snacks, how often does he/she wash hands with soap and water? *(asked in case of child self-feeding)*
Hand washing after cleaning child's bottom	After cleaning child's bottom, how often do you wash your hands with soap and water

Notes. Response scales: 5-point Likert scale [from 'not at all' to 'very much'; from 'at no time' to 'almost each time'; from 'never' to 'very often'; from 'nobody' to 'almost all of them'], [yes; no; I don't know].

Appendix 3B: Questionnaire based on the RANAS model for washing kitchen utensils with soap behaviour

Behaviour factors	**Selected Items**
Risk Factors	
Vulnerability	In general, how high do you think is the risk that you get dirrhoea?
Attitudinal Factors	
Belief effort	How effortful do you think is washing utensils with soap and water?
Belief time consuming	How time consuming do you think it is to always wash utensils with soap and water?
Belief pleasant	How pleasant is it for you to always wash utensils with soap and water?
Normative Factors	

Others’ behaviour household	How many people of your household always wash utensils with soap and water?
Others’ behaviour village	How many people of your village always wash utensils with soap and water?
Others’ approval	People who are important to you like your family members, friends, the chief of the village, NGO workers or Pastor, how much they approve that you always wash utensils with soap and water?
Personal obligation	How strong do you feel a personal obligation to yourself to wash utensils with soap and water?
Ability Factors	
Confidence in performance	How sure are you that you can wash utensils with soap and water?
Difficult water	How difficult is to get as much water as you need to always wash utensils with soap and water?
Difficult soap	How difficult is to get much soap as you need to always wash utensils with soap and water?
Confidence in performance (hurry)	How sure are you that you can always wash utensils with soap even if you are in hurry?
Confidence in performance (recovery)	If you stopped washing utensils with soap for other reasons, how sure are you that you can restart washing utensils with soap and water?
Self-Regulation Factors	
Remembering (pay attention)	How much do you pay attention to always have enough soap at home to wash utensils with soap and water?
Remembering (forgetting last 24h)	When you think about the last 24 hours: How often did it happen that you forgot to wash utensils with soap and water?
Commitment (important)	How important is it for you to wash utensils with soap and water?
Commitment (committed)	How committed do you feel to wash utensils with soap and water?
Additional factor	How often do you discuss with others about washing utensils with soap and water
Self-reported Behaviour	
Washing kitchen utensils with soap	Before you use kitchen utensils, how often do you wash them with soap and water

Notes. Response scales: 5-point Likert scale [from ‘not at all’ to ‘very much’; from ‘at no time’ to ‘almost each time’; from ‘never’ to ‘very often’; from ‘nobody’ to ‘almost all of them’].

Appendix 3C: Questionnaire based on the RANAS model for keeping kitchen utensils on safe place behaviour

Behaviour factors	**Selected Items**
Risk Factors	
Vulnerability	In general, how high do you think is the risk that you get dirrhoea?

Attitudinal Factors	
Belief effort	How effortful do you think is to keep utensils on an elevated place?
Belief time consuming	How time consuming do you think it is to always keep utensils on an elevated place?
Belief pleasant	How pleasant is it for you to always keep utensils on an elevated place?
Normative Factors	
Others' behaviour household	How many people of your household always keep utensils on an elevated place?
Others' behaviour village	How many people of your village always keep utensils on an elevated place?
Others' approval	People who are important to you like your family members, friends, the chief of the village, NGO workers or Pastor, how much they approve that you always keep utensils on an elevated place?
Personal obligation	How strong do you feel a personal obligation to yourself to keep utensils on an elevated place?
Ability Factors	
Confidence in performance (no place)	How confident are you that you can keep kitchen utensils on an elevated place even if this is difficult sometimes (e.g. because of no dish rack)?
Confidence in performance (hurry)	How sure are you that you can always keep utensils on an elevated place even if you are in hurry?
Confidence in performance (recovery)	If you stopped washing utensils with soap for other reasons, how sure are you that you can restart keeping utensils on an elevated place?
Confidence in performance (can't do so)	How often does it happen that you want to keep kitchen utensils on an elevated position but can't do so?
Self-Regulation Factors	
Remembering (pay attention)	How much do you pay attention to always keep utensils on an elevated place?
Remembering (forgetting last 24h)	When you think about the last 24 hours: How often did it happen that you forgot to keep utensils on an elevated place?
Commitment (important)	How important is it for you to keep utensils on an elevated place?
Commitment (committed)	How committed do you feel to keep utensils on an elevated place?
Additional factor	How often do you discuss with others about keeping utensils on an elevated place
Self-reported Behaviour	
Keeping kitchen utensils safe (on elevated place)	Do you keep your kitchen utensils on an elevated place

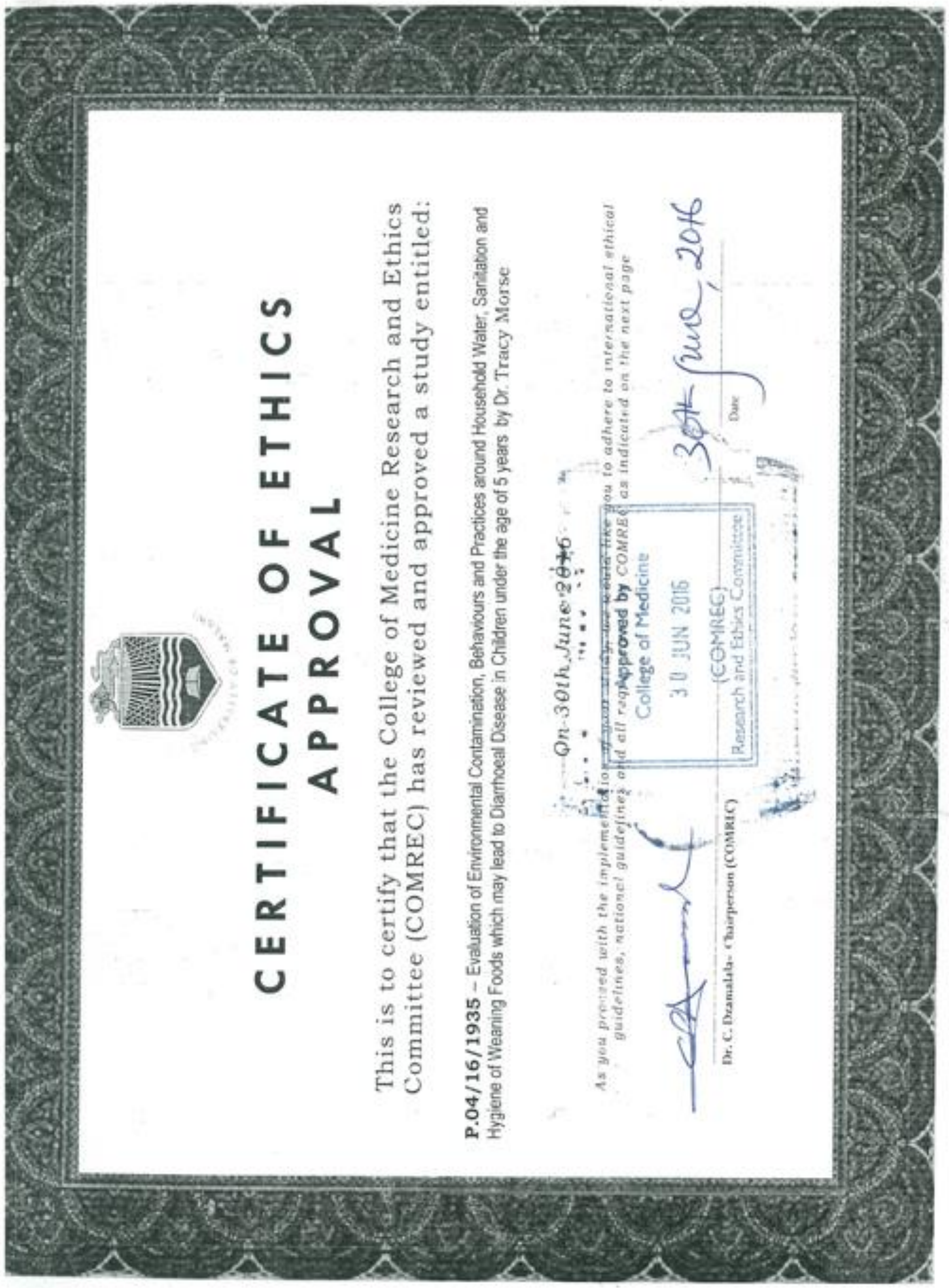
Notes. Response scales: 5-point Likert scale [from 'not at all' to 'very much'; from 'at no time' to 'almost each time'; from 'never' to 'very often'; from 'nobody' to 'almost all of them'].

Appendix 4: WHO sub – regions in detail (Source: (WHO, 2015c)

Sub - Region	WHO member states
AFR D	Algeria; Angola; Benin; Burkina Faso; Cameroon; Cabo Verde; Chad; Comoros; Equatorial Guinea; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Liberia; Madagascar; Mali; Mauritania; Mauritius; Niger; Nigeria; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; Togo.
AFR E	Botswana; Burundi; Central African Republic; Congo; Cote d'Ivoire; Democratic Republic of the Congo; Eritrea; Ethiopia; Kenya; Lesotho; Malawi; Mozambique; Namibia; Rwanda; South Africa; Swaziland; Uganda; United Republic of Tanzania; Zambia; Zimbabwe.
AMR A	Canada; Cuba; United States of America.
AMR B	Antigua and Barbuda; Argentina; Bahamas; Barbados; Belize; Brazil; Chile; Colombia; Costa Rica; Dominica; Dominican Republic; El Salvador; Grenada; Guyana; Honduras; Jamaica; Mexico; Panama; Paraguay; Saint Kitts and Nevis; Saint Lucia; Saint Vincent and the Grenadines; Suriname; Trinidad and Tobago; Uruguay; Venezuela (Bolivarian Republic of).
AMR D	Bolivia (Plurinational State of); Ecuador; Guatemala; Haiti; Nicaragua; Peru.
EMR B	Bahrain; Iran (Islamic Republic of); Jordan; Kuwait; Lebanon; Libya; Oman; Qatar; Saudi Arabia; Syrian Arab Republic; Tunisia; United Arab Emirates.
EMR D	Afghanistan; Djibouti; Egypt; Iraq; Morocco; Pakistan; Somalia; South Sudan; Sudan; Yemen.
EUR A	Andorra; Austria; Belgium; Croatia; Cyprus; Czech Republic; Denmark; Finland; France; Germany; Greece; Iceland; Ireland; Israel; Italy; Luxembourg; Malta; Monaco; Netherlands; Norway; Portugal; San Marino; Slovenia; Spain; Sweden; Switzerland; United Kingdom.
EUR B	Albania; Armenia; Azerbaijan; Bosnia and Herzegovina; Bulgaria; Georgia; Kyrgyzstan; Montenegro; Poland; Romania; Serbia; Slovakia; Tajikistan; The Former Yugoslav Republic of Macedonia; Turkey; Turkmenistan; Uzbekistan.
EUR C	Belarus; Estonia; Hungary; Kazakhstan; Latvia; Lithuania; Republic of Moldova; Russian Federation; Ukraine.
SEAR B	Indonesia; Sri Lanka; Thailand.
SEAR D	Bangladesh; Bhutan; Democratic People's Republic of Korea; India; Maldives; Myanmar; Nepal; Timor-Leste.
WPR A	Australia; Brunei Darussalam; Japan; New Zealand; Singapore.
WPR B	Cambodia; China; Cook Islands; Fiji; Kiribati; Lao People's Democratic Republic; Malaysia; Marshall Islands; Micronesia (Federated States of); Mongolia; Nauru; Niue; Palau; Papua New Guinea; Philippines; Republic of Korea; Samoa; Solomon Islands; Tonga; Tuvalu; Vanuatu; Viet Nam.

Notes: (1) The sub-regions are defined on the basis of child and adult mortality. Stratum A = very low child and adult mortality; Stratum B = low child mortality and very low adult mortality; Stratum C = low child mortality and high adult mortality; Stratum D = high child and adult mortality; and Stratum E = high child mortality and very high adult mortality. The use of the term sub-region' here and throughout the text does not identify an official grouping of WHO Member States, and the "sub-regions" are not related to the six official WHO regions, which are AFR = African Region; AMR = Region of the Americas; EMR = Eastern Mediterranean Region; EUR = European Region; SEAR = South-East Asia Region; WPR = Western Pacific Region.

Appendix 5: Ethical approval from University of Malawi College of Medicine to conduct the Food Hygiene Intervention Study


CERTIFICATE OF ETHICS APPROVAL

This is to certify that the College of Medicine Research and Ethics Committee (COMREC) has reviewed and approved a study entitled:

P.04/16/1935 – Evaluation of Environmental Contamination, Behaviours and Practices around Household Water, Sanitation and Hygiene of Weaning Foods which may lead to Diarrhoeal Disease in Children under the age of 5 years by Dr. Tracy Morse

On 30th June 2016

As you proceed with the implementation of your study, we would like you to adhere to international ethical guidelines, national guidelines and all requirements by COMREC as indicated on the next page

Approved by College of Medicine 30 JUN 2016 (COMREC) Research and Ethics Committee

Dr. C. Dzamalala - Chairperson (COMREC)

30th June, 2016

Date

Appendix 6: Participant Information Sheet

All consent forms to be used in the research project will be specific to the activity being undertaken, and will be translated to Chichewa for easy understanding of participants. All consent forms will be read to the participant, as well as provided for further reading at a later point.

Part A: Respondent information sheet

This work involves research and will be done by MEIRU and University of Malawi (Polytechnic and College of medicine) with funding from DFID through SHARE.
This research is aimed at improving the sanitation and hygiene conditions of weaning food for the under five children in your household. You may receive some advice and support on hygiene practices within your home both directly and through group discussions. During the period of follow up, eating patterns of communities and health status of children will be monitored through health passports and interviews to check if they affect food hygiene and safety. This research will take a maximum of one year from the day observations start. No part of this research will be experimental and presents no risk or discomfort to participants of the study.

If your household accepts to continue taking part, you will be asked questions on the practices and behaviours on eating patterns, food hygiene and sanitation. We will be collecting food samples and stools from your child/children.

Agreeing to take part in this research

We do not anticipate that any harm will come to people through their participation and sampling in the research.
Please note that your participation and allowing your household to be included in the study is entirely voluntary. If you don't want to take part, you can refuse without any penalty or loss of benefits to you. If you do agree to participate and then change your mind, please tell the researchers and they will end your participation and withdraw your household immediately, without any penalty or loss of benefits to you. You can do this at any point during this study.
We will inform you of any significant new findings during the study which may affect your willingness to continue.

Compensation
Note that there is no compensation of any kind for participation in this study. However you will benefit from increased understanding of good hygiene practices at household level, which may improve the health status of you and your family.

Confidentiality

As a participant in the research be assured that all the information you provide will be treated in confidence. This means that your name or any name of household members will not be used when we write our reports about the research. It also means that no one outside the research team will know how you as an individual answered the questions. No photographs, video or audio material arising from your participation in this study will be included in any reports, even anonymously, without your agreement.

Part B: Consent Form

MEIRU, University of Malawi (Polytechnic and College of Medicine) and SHARE, with funding from DFID will conduct a study in the next three years (2015-2018) on food hygiene and weaning foods for under five children.

We are asking your household (specifically your under five child/children to be included in the food hygiene/WASH interventions so that we can understand more about the eating patterns, food hygiene and sanitation of your household and community especially for the under five children.

I would like to assure you that your responses will be kept confidential.

Name...

Address..

1. Have you read or listened to the respondent information sheet? Yes / No
2. Have you had the opportunity to ask questions? Yes / No
3. Have your questions been answered, and do you feel that you have had enough information about this study? Yes / No
4. Do you understand that you are free to withdraw from the study at any time without giving a reason and without any penalties? Yes / No
5. Do you understand that data collected during the study may be looked at by individuals from SHARE, MEIRU and University of Malawi? Yes / No

If you have answered 'yes' to all these questions, please sign the form, or place a thumbprint below, which means that you voluntarily agree to enter the study.

I voluntarily agree to enter this study.

Signature/thumb print... Date …………………………..

Witness to consent if participant unable to sign their name (name in capitals)……………………….

Signature/thumb print ……………………………………… Date…………………………..

Investigator obtaining consent (name in capitals)…………………………………..

Signature .... Date ………………………..

More information

For further questions about this research, please contact: Dr. Tracy Morse, Polytechnic, WASHTED, P/Bag 303 Chichiri, Blantyre 3. Email: tracythomson@africa-online.net

For information pertaining to ethical approval of this research contact:
COMREC Administrator
College of Medicine, University of Malawi
3rd Floor - John Chiphangwi Learning Resource Centre
Private Bag 360
Chichiri
Blantyre 3
Malawi

Appendix 7: Research Project Pictures

Figure 28: Hand paper print game exercise to reinforce handwashing with soap behaviour

Figure 29: Household interview

Figure 30: Tippy Tap handwashing facility under a dish rack

Figure 31: Banting with food hygiene messages placed inside the house

Figure 32: Open day banner

Figure 33: Hygienic family illustration

Figure 34: A child wearing a bib with a handwashing with soap message